USING ASSIST FOR AIRCRAFT INSPECTION TRAINING: PERFORMANCE AND USABILITY ANALYSIS

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1.1 INTRODUCTION

This report is divided into seven major sections. The Background outlines the need for training in inspection. The next three sections detail the ASSIST development effort, introduce the reader to its evaluation effort, and outline the methodology used to evaluate this system, respectively. Sections on performance and usability analysis describe the results of the evaluation effort. Finally the Conclusion outlines the implications of this study in using computer-based inspection training for improving aircraft inspection performance. This research was conducted with various industry partners to ensure its relevance and applicability to the aviation maintenance community.

1.2 BACKGROUND

The aircraft inspection/maintenance system is a complex one with many interrelated human and machine components.14,4 One of the major factors contributing to this complexity is the aging fleet. Scheduled repairs to an older fleet account for only 30% of all maintenance compared to the 60-80% for a newer one. This difference can be attributed to the increase in the number of age-related defects.4 In such an environment the importance of inspection cannot be overemphasized. It is critical that these visual inspections be performed effectively, efficiently, and consistently over time. Moreover, because 90% of all inspection in aircraft maintenance is visual in nature and is conducted by inspectors, inspector reliability is fundamental to an effective maintenance system.

Since it is difficult to eliminate errors altogether, continuing emphasis must be placed on developing interventions to make inspection and maintenance more reliable and/or more error tolerant. Training has been identified as the primary intervention strategy in improving inspection performance. If training is to be successful, we need to provide inspectors with training tools to help enhance their inspection skills. Existing training for inspectors in the aircraft maintenance environment tends to be mostly on-the-job training (OJT). However, this method may not be the best one because feedback may be infrequent, unmethodical, and/or delayed.9,12 Moreover, in certain instances, feedback is economically prohibitive or impractical because of the nature of the task. Because the benefits of feedback in training have been well documented, and for other reasons as well, alternatives to OJT are sought.27

More importantly, training for improving the visual inspection skills of aircraft inspectors is generally lacking at aircraft repair centers and maintenance facilities even though the application of training knowledge to enhance visual inspection skills has been well documented in the manufacturing industry where training has been shown to improve the performance of both novice and experienced inspectors.27,7 Visual inspection skills can be taught effectively using representative photographic images showing a wide range of conditions with immediate feedback on the trainee's decision, a combination of training methods that has also been shown to be superior to OJT alone.27,20 A case study presented by Gramopadhye et al. showing how photographic images and feedback were used to develop a computer-based training program for a contact lens inspection task supports the findings of the Latorella et al.16,20

The success of off-line training/retraining with feedback suggests that this method can play a role in aircraft inspection training. One of the most viable approaches for delivering training, given the many constraints and requirements imposed by the aircraft maintenance environment, is computer-based training. Computer-based training offers several advantages over traditional training approaches: it is more efficient white at the same time facilitating standardization, and supporting distance learning. One recent example is the Aircraft Maintenance Team Training (AMTT) Program that is specifically designed to teach aircraft maintenance technicians basic team skills using a multimedia approach with interaction opportunities between the user and the computer.15 With computer technology becoming cheaper, the future will bring an increased application of advanced technology to training.

In the domain of visual inspection, the earliest efforts to use computers for off-line inspection training were reported by Czaja et al. who used keyboard characters to develop a computer simulation of a visual inspection task.2 Similar simulations have also been used by other researchers to study inspection performance in a laboratory setting.[21] Since these early efforts, Latorella et al. and Gramopadhye et al. have used low fidelity inspection simulators and computer-generated images to develop off-line inspection training programs for airframe inspection tasks.13,20 Similarly, Kundel et al. studied the application of advanced technology in relation to the inspection of x-rays in medical practice and Drury et al. studied human performance using a high fidelity computer simulation of a printed circuit board inspection.19,6 More recently, Blackmon et al. have reported the development of an inspection simulator using scanned images of airframe structures for aircraft inspection training.1 In summary, most of the work in the application of advanced technology to inspection training has focused on developing low-fidelity simulators for running controlled studies in a laboratory environment as for example, the computer-simulated line judgement task conducted by Micalizzi et al., or it has been off-line training in non-manufacturing areas, for example, the aircraft inspection domain.22 But advanced technology has found limited application in industrial tasks, specifically the inspection tasks that exist in today's manufacturing industry. The primary exception is the use of simulators which have moved beyond the aviation industry and military applications to chemical and nuclear plants.[11,18] The message is clear: we need more examples of the application of advanced technology to training for inspection tasks, examples that draw upon the principles of training that we already know work. To answer this need, this case study demonstrates the application of advanced technology to inspection training for aircraft inspectors.

1.2.1 Training

Patrick has identified training content, training methods and the trainee as the important components of the training program.24 Drury includes the training delivery system as another component.5 Training methods that have been used effectively for inspection training are described below.7,14

Pre-training

Pre-training provides the trainee with information concerning the objectives and scope of the training program. During pre-training, pretests can be used to measure the level at which trainees enter the program and the cognitive or perceptual abilities that can be used later to gauge the training performance/progress. Advanced organizers or overviews, which give the trainee an introduction to the program and facilitate the assimilation of new material fulfill the elaboration theory of instruction which proposes that training should be imparted in a top-down manner with the general level being taught before the specifics.

Feedback

A trainee needs rapid, accurate feedback in order to know whether a defect was classified correctly or a search pattern was effective. Gramopadhye et al. classify feedback as either performance or process feedback.14 Performance feedback typically consists of information on search times, search errors and decision errors. Process feedback, on the other hand, informs the trainee about the search process, such as areas missed. Feedback with knowledge of results coupled with some attempt at performing the task provides a universal method of improving task performance which can be applied to learning facts, concepts, procedures, problem solving, cognitive strategies and motor skills.27 A training program should start with rapid feedback, which should then be gradually delayed until the "operational level" is reached. Providing regular feedback beyond the training session helps to keep the inspector calibrated.

Active Training

To keep the trainee involved in the training and to aid in internalizing the material, an active approach is preferred. In active training, the trainee actively responds after each new piece of material is presented, as, for example, in identifying a fault type. Czaja et al. demonstrated the effectiveness of this approach for a complex inspection task.2

Progressive Parts Training

In the progressive parts methodology, parts of the job are taught to criterion and then successively larger sequences of parts are taught. For example, a task consisting of four elements-- E1, E2, E3 and E4--would be taught as follows:

E1, E2, E3 and E4 would be trained separately to criterion

E1 and E2, E2 and E3, and E3 and E4 would be trained to criterion

E1, E2 and E3 would be trained to criterion then E2, E3 and E4 would be trained to criterion

The entire task would be trained to criterion

This method allows the trainee to understand each element separately as well as to understand the links between the various elements, thus lending to a higher level of skill. Salvendy et al. successfully applied progressive part training methodology to training industrial skills reviews of the literature on this method reveals progressive parts training is not always superior.25 The choice of whether training should be part or whole task depends on the "cognitive resources" imposed by the task elements and the "level of interaction" between individual task elements.12 Thus, there could be situations in which one type of task training is more appropriate than the other. Naylor et al. have postulated that for tasks of relatively high organization or complexity, whole task training would be more efficient than part-task training methods.23

Schema Training

Schema training lets the trainee generalize the training to new experiences and situations. For example, it is impossible to train an inspector on every site and extent of corrosion in an airframe. Thus, the inspector needs to develop a "schema" to allow a correct response to be made in unfamiliar situations. The key to the development of schema is to expose the trainee to controlled variability in training.

Feedforward Training

Feedforward training cues the trainee as to what should be perceived. For example, when novice inspectors try to find defects in an airframe, the indications may not be obvious, unless they know what to look for and where to look. Feedforward information can take different forms such as physical guidance, demonstrations, and verbal guidance. Specific cueing techniques include match-to-sample and delayed match-to-sample. Feedforward should provide the trainee with clear and unambiguous information which can then be translated into improved performance.

1.2.2 Training Delivery Systems

Training delivery systems can be classified as Classroom Training, On-the-Job Training and Computer-Based-Training.14 Gordon, who develops a detailed taxonomy of delivery systems listing the advantages and disadvantages of each, indicates that the choice of the specific delivery system depends on such factors as the knowledge that needs to be transferred, the user's background and experience, the implementation and development costs, the time available, and the flexibility.12

Training methods along with an appropriate delivery system comprise an effective training system. The following section describes the use of these components and the task analytic methodology used to develop a computer-based aircraft inspection training program called the Automated System of Self Instruction for Specialized Training (ASSIST).

1.3 ASSIST Development

1.3.1 Task Analysis

The development of the ASSIST Program followed the classic training program development methodology. It began with a thorough analysis of the requirements and the needs or goals of the training program. The next step was to establish the training group and identify the trainers and participants who would be involved. Next, a detailed task analysis of the job was conducted to determine the knowledge, skills, and abilities necessary for the job in order to specify the behavioral objectives of the training program. These objectives became the basis for evaluating the training program. The next step was to define the criteria against which the inspectors would be trained and their performance measured to meet the quality goals. The abilities of the incoming trainees were compared to the requirements imposed by the task to determine the gaps and, hence, define the contents of a training program that would help close these gaps and meet the defined criteria. At this stage, the appropriate training delivery system, i.e., the instructional technique such as Tutoring, OJT or Computer-Aided Instruction had to be chosen. Once the training system was designed and developed, was evaluated to determine it met the ultimate goals. The designer choose criteria to be used for evaluation, identified a method and protocol for collecting evaluation data, and analyzed the data to draw conclusions about the effectiveness of the training program.

Following this step, a detailed taxonomy of errors was developed from the failure modes of each task in aircraft inspection (Table 1.1). This taxonomy, based on the failure modes and effects analysis (FMEA) approach, was developed because of the realization that a pro-active approach to error control is necessary for the identification of potential errors. Thus, the taxonomy was aimed at the phenotypes of error, that is, the observed errors.17 Using the generic task description of the inspection system, the goal or outcome of each task was postulated (Table 1.1). These outcomes then formed the basis for identifying the failure modes of each task, and including the operational error data gained from the observations of inspectors and from discussions with various aircraft maintenance personnel, collected over a period of two years. Later the frequency of error was estimated, after which the consequences of the errors on system performance were deduced. The error taxonomy provided the analysts with a systematic framework to suggest appropriate content for the ASSIST training program. The ASSIST training program specifically focused on the search and decision- making components of the inspection task. These have also been shown to be determinants of inspection performance and the two most critical tasks in aircraft inspection.3,26,4,10

Table 1.1 Task and Error Taxonomy for Visual Inspection (e.g. decision component)

TASK	ERRORS	OUTCOME
DECISION		
4.1 Interpret indication.	Classify as wrong fault type.	All indications located are correctly classified, correctly labeled as fault or no fault, and actions correctly planned for each indication.
4.2 Access comparison standard.	Choose wrong comparison standards.	
	Comparison standard not available.	
	Comparison standard not correct.	
	Comparison incomplete.	
	Does not use comparison standard.	
4.3 Decide on if fault.	Type I error, false alarm.	
	Type II error, missed fault.	
4.4 Decide on action.	Choose wrong action.	
	Second opinion if not needed.	
	No second opinion if needed.	
	Call for buy-back when not required.	
	Fail to call for required buy-back.	
4.5 Remember decision/action.	Forget decision/action.	
	Fail to record decision/action.	

1.3.2 Structure of ASSIST

The overall structure of the ASSIST program is divided into three modules: General Module, Simulation, and Instructor’s Module (Figure 1.1). The ASSIST training program is divided into the following subtasks: decision-making task, the training content of ASSIST that addresses this task, the method by which the content is presented, the module in which the content is presented, and the error addressed from task analysis, which is identified from the error taxonomy (Table 1.2).

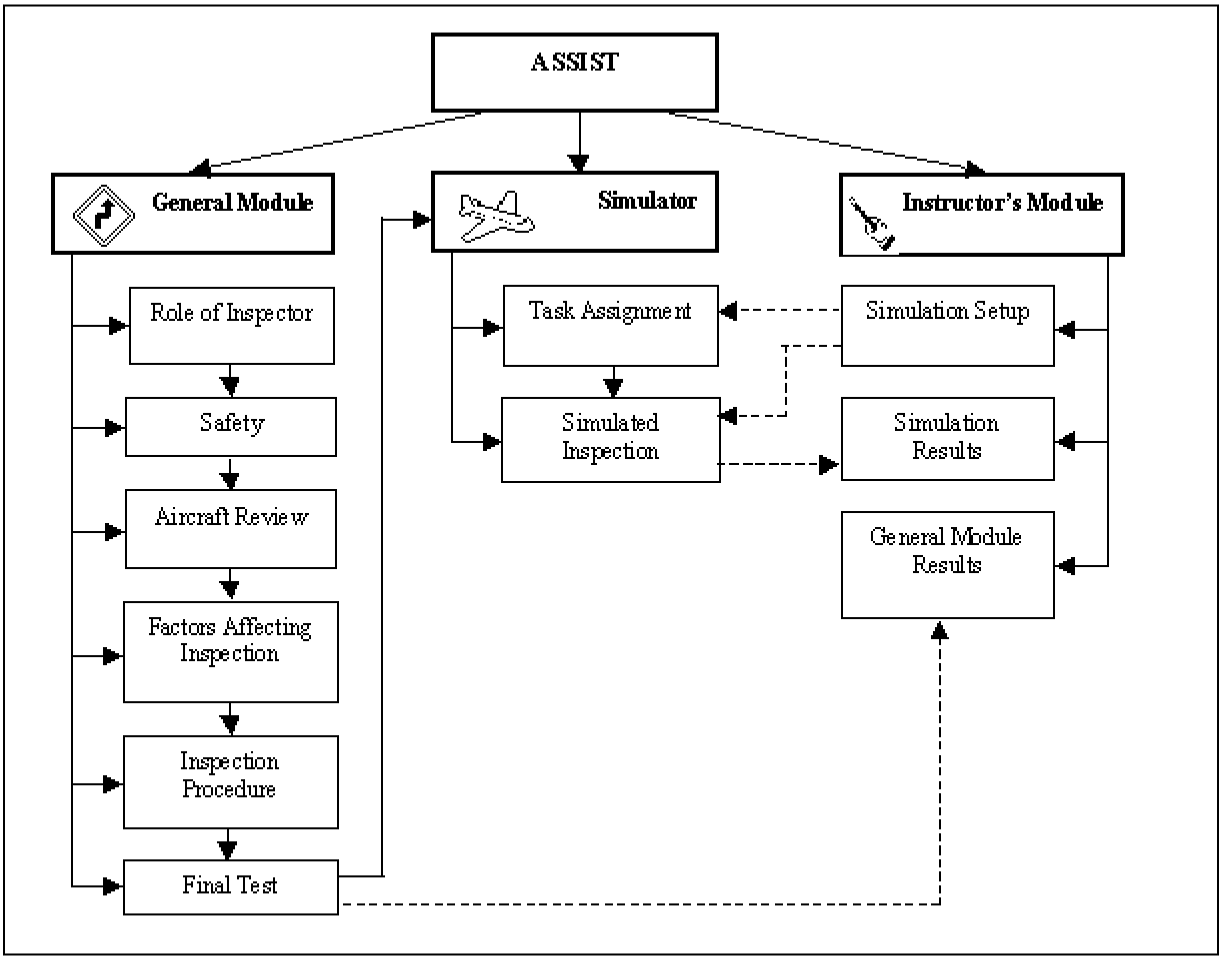

Figure 1.1 Components of the ASSIST Aircraft Inspector Training Program

Table 1.2 ASSIST Program: Showing Errors Addressed for the Decision Task

ASSIST TRAINING PROGRAM				
TASK	**CONTENT OF ASSIST**	**METHOD**	**PROGRAM MODULE**	**ERROR ADDRESSED FROM TASK ANALYSIS**
DECISION				
4.1 Interpret indication	**Present examples of defects and identify in simulator**	**Active and Feedback**	**General Module, Simulator**	• **Classify as wrong fault type**
4.2 Access comparison standard	**Use simulator to access information on defects, locations, and action**	**Active and Feedback**	**General Module, Simulator**	• **Choose wrong comparison standards** • Comparison standard not available • Comparison standard not correct • Comparison incomplete • Does not use comparison standard
4.3 Decide on if it's a fault	Use simulator with real defects and feedback	Progressive parts, Active, and	Simulator	• Type I error, false alarm

		Feedback		• Type II error, missed fault
4.4 Decide on action	Complete NR card with Feedback in correct way to fill out card	Active and Feedback	Simulator	• Choose wrong action
4.5 Remember decision/ action	Enter multiple defects and complete NR card with feedback	Active and Feedback	Simulator	• Forget decision/action • Fail to record decision/action

System Structure

ASSIST consists of three major modules: (1) the General Inspection Module, (2) the Inspection Simulation Training Module, and (3) the Instructor's Utilities Module. All system users interact through a user-friendly interface which capitalizes on graphical user interface technologies and human factors research on information presentation (e.g., color, formatting, layout, etc.), ease of use, and information utilization.

System Specification

The ASSIST program needs at least a Pentium 100, with a 166 Pentium or faster suggested. A minimum hard drive space of 220 MB is required with at least 24 MB of memory, with 64 MB being the suggested memory. It runs on a Windows 95, or higher, operating system. The program also requires a SoundBlaster compatible sound card and 8X CD-ROM. The display requirements are 640 X 480 resolution with a high color (16 bit) palette. The system's input devices are a keyboard and a mouse.

General Module

The objective of the general module, which presents information through text, pictures, audio, and video, is to provide the inspectors with an overview of the following sub-modules: (1) role of the inspector, (2) safety, (3) aircraft review, (4) factors affecting inspection, and (5) inspection procedure. The module is based on presenting information through various media of text, pictures, audio, and video. At the end of each sub-module is a three-question quiz to reinforce the information learned. Development of the General Module was an iterative process involving regular feedback from industry partners on the content of each sub-module. Below are detailed descriptions of each sub-module.

Introduction

The Introduction sub-module allows the inspector to log in to the program (Figure 1.2). If this is the first time the inspector has used ASSIST, the inspector's record is created in the student database and a brief introduction to the program is shown. This introduction emphasizes the importance of the inspector's role in aircraft maintenance and the need for good training. If the inspector has used the ASSIST program before, the navigation sub-module is displayed.

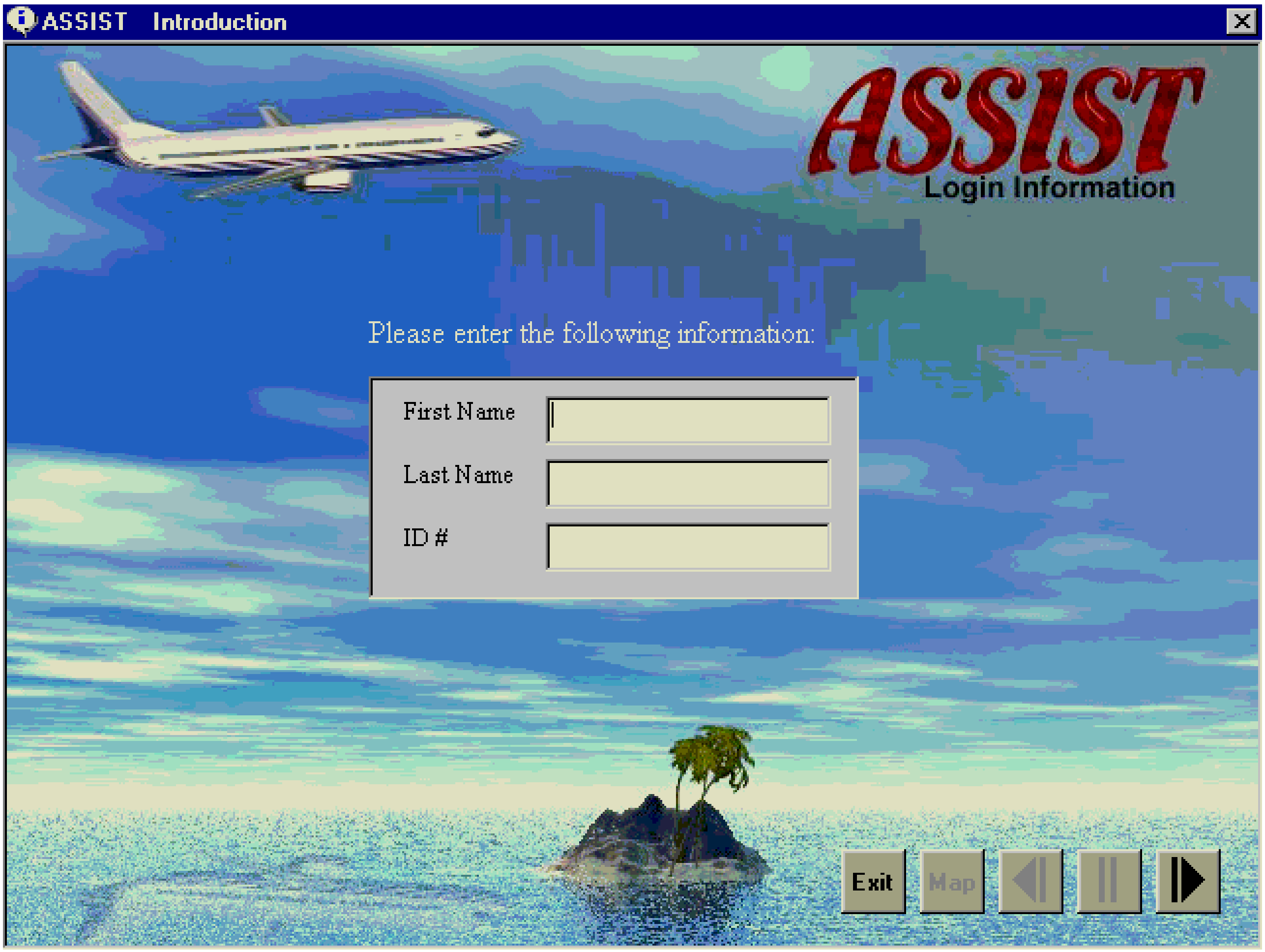

Figure 1.2 Login Screen for the ASSIST Training Program

Navigation

The Navigation sub-module allows the inspector to move between the sub-modules of the ASSIST program. It displays the five content sub-modules on the left of the screen and their parts in the center (Figure 1.3).

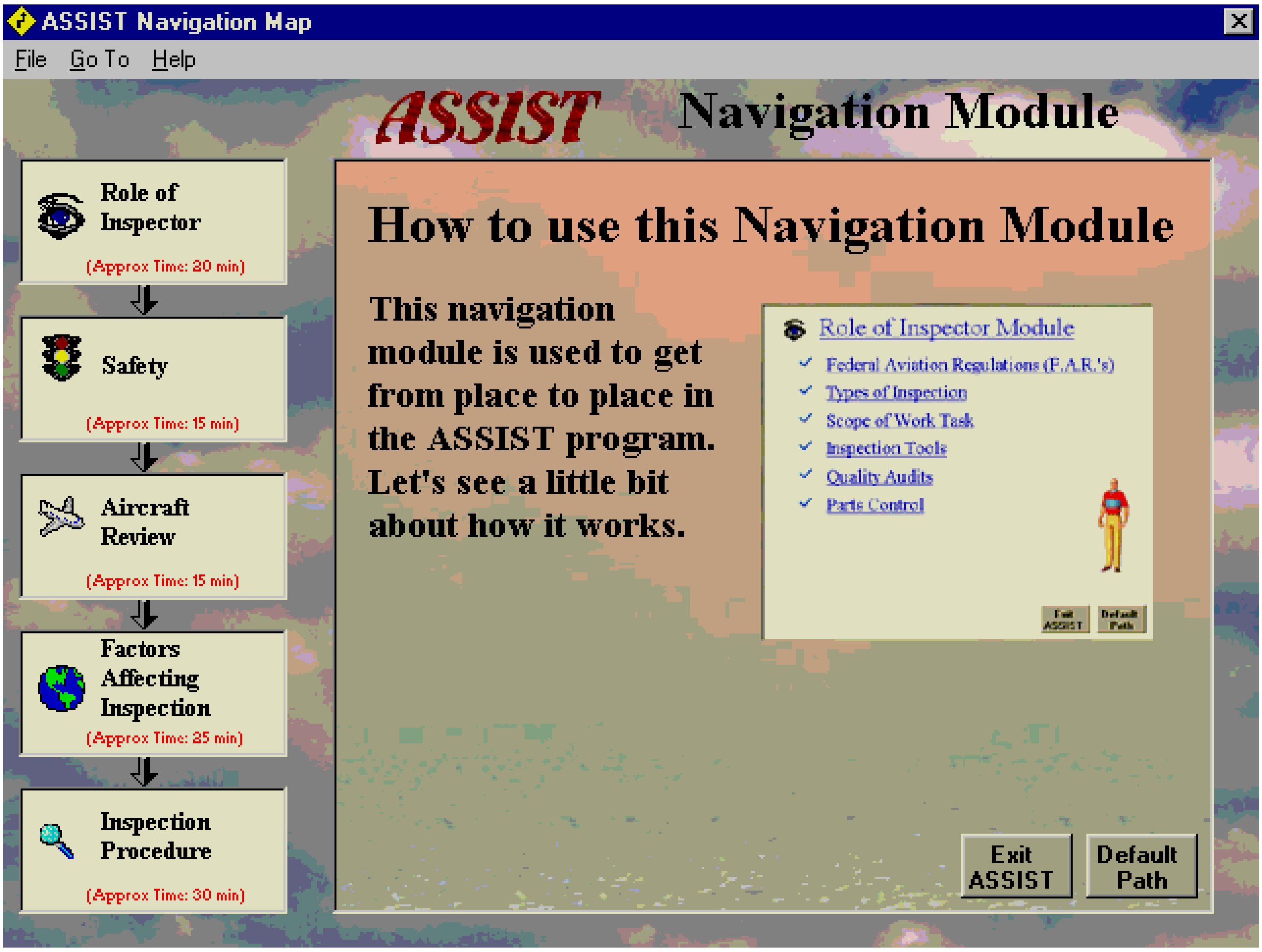

Figure 1.3 ASSIST Navigation Map for Moving within the General Module

Role of Inspector

The Role of Inspector sub-module covers topics dealing with the role and scope of the inspector's job including information on the definitions of an inspector according to the Federal Aviation Regulations (FAR), the scope of the inspector's work, the and inspection tools--flashlight, magnifying glass, scraping knife, and mirror (Figure 1.4).

Figure 1.4 Role of Inspector Sub-module Covering Inspection Tools

Safety

The Safety sub-module covers the two major areas of safety related to the inspector's general environment: safety in the maintenance hangar and safety issues specific to the inspector. Topics include hearing safety, accessing the aircraft, and foreign object damage (Figure 1.5).

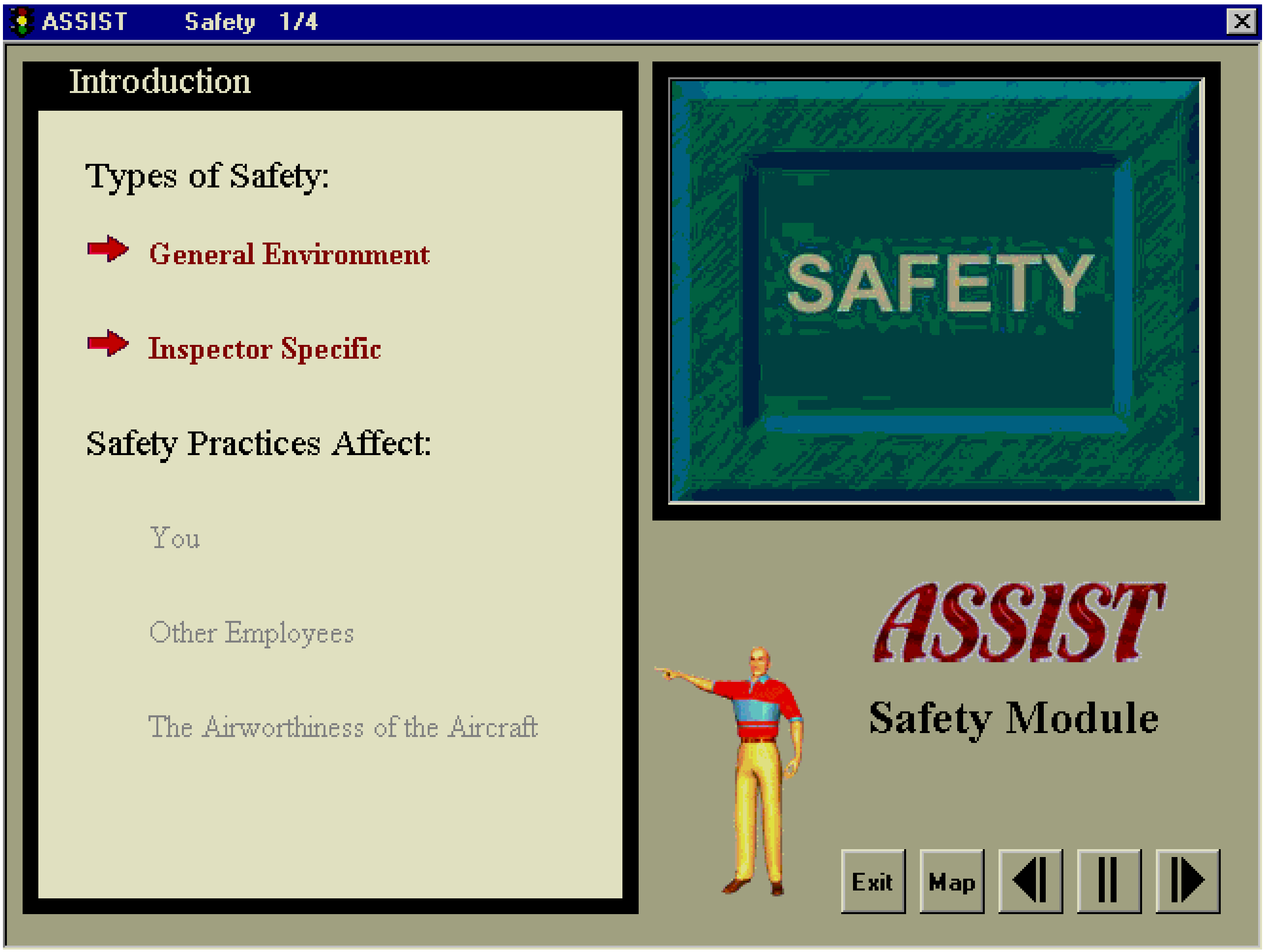

Figure 1.5 Introduction to the Safety Sub-module

Aircraft Review

The inspector goes through a review of various aircraft that are in production and in service today in the Aircraft Review sub-module. A general discussion of defects and their potential frequency in the aircraft is followed by a review of the major commercial aircraft from Airbus, Boeing, Lockheed-Martin, and McDonnell Douglas (Figure 1.6).

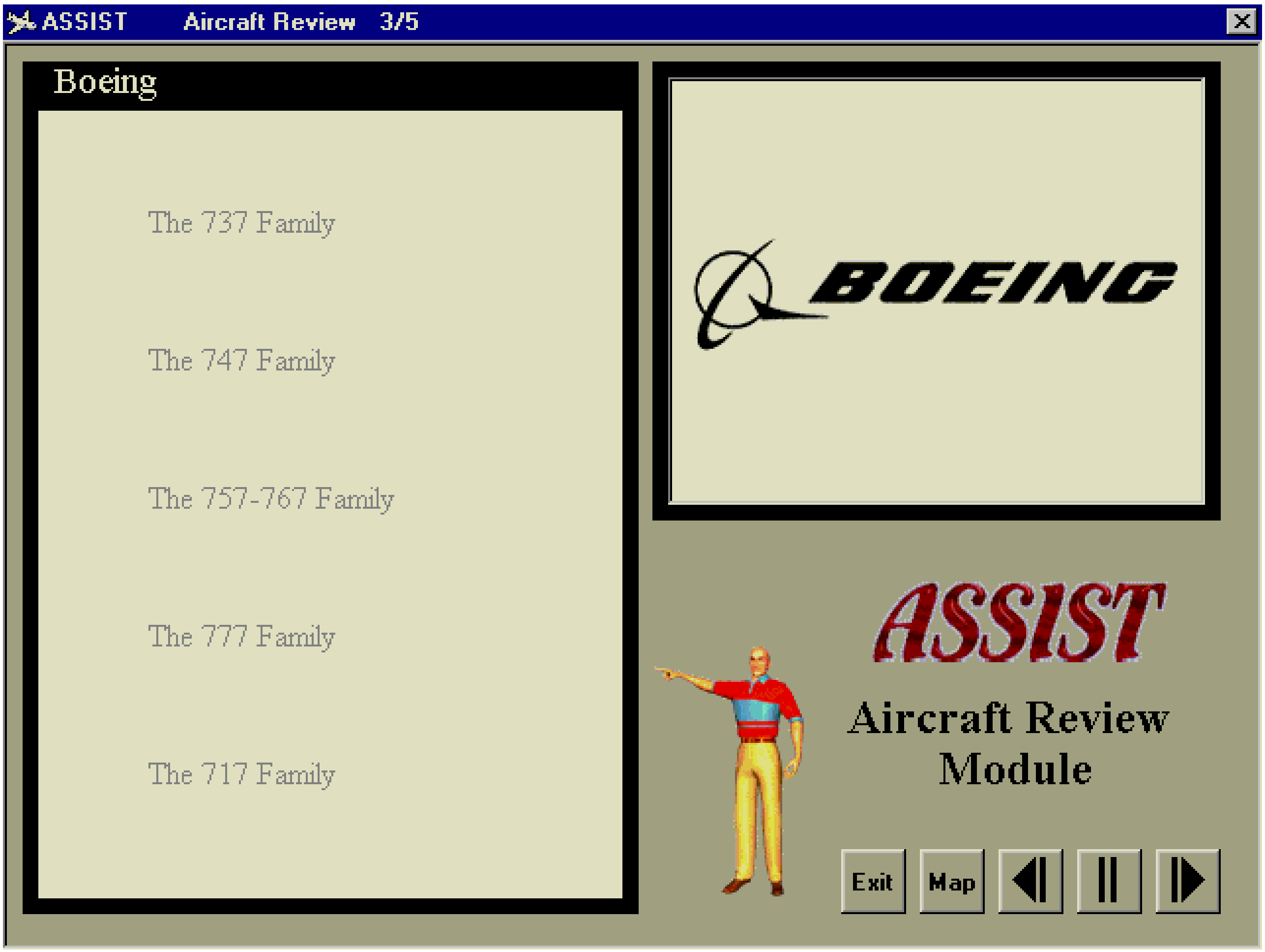

Figure 1.6 Aircraft Review Sub-module Covering Boeing Aircraft

Factors Affecting Inspection

The Factors Affecting Inspection sub-module covers the various factors that can affect the inspector, including environmental, subject, process, and information factors (Figure 1.7). Detailed information is presented for each.

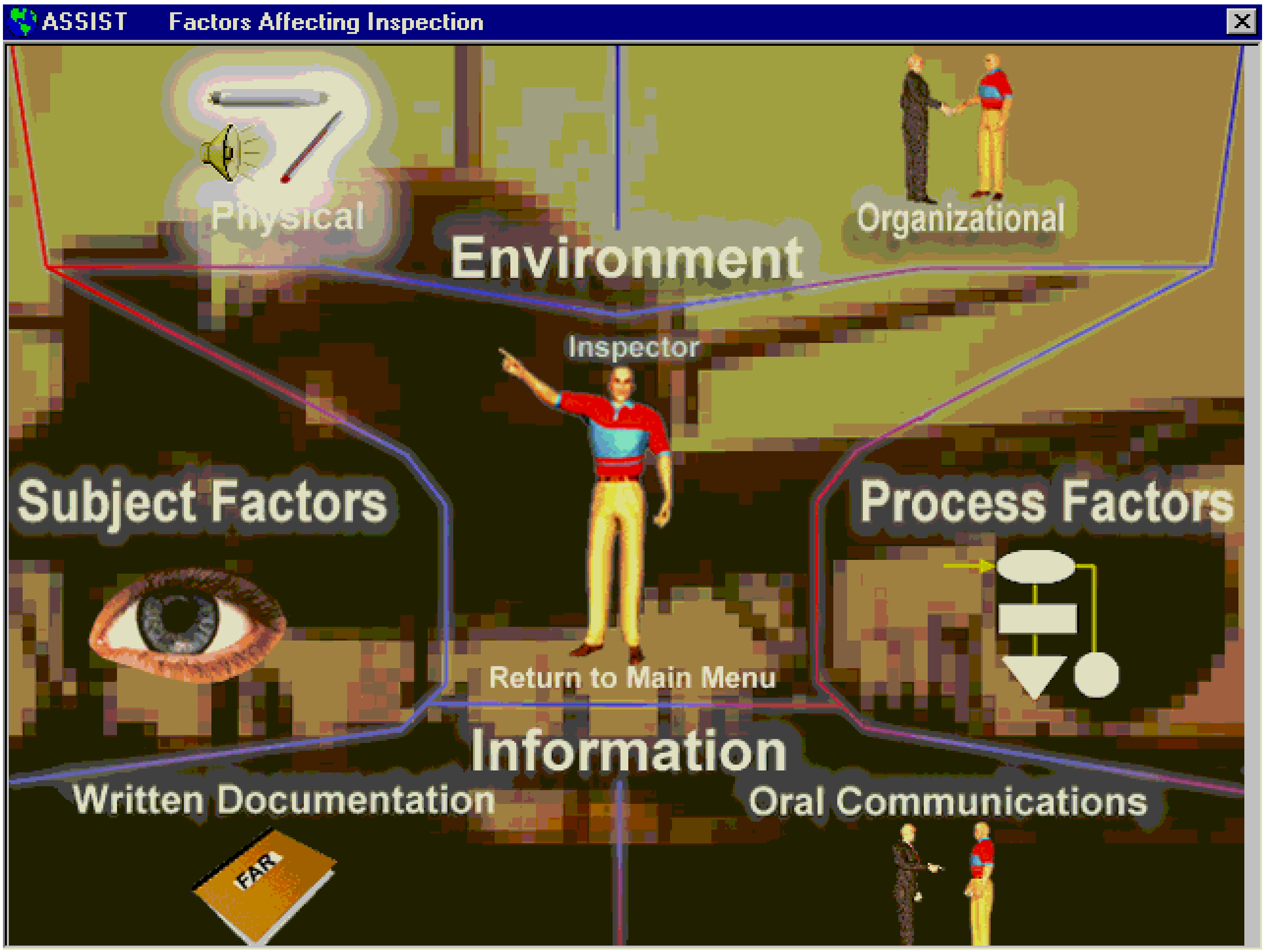

Figure 1.7 Menu of Factors Affecting Inspection Sub-Module

Inspection Procedure

The Inspection Procedure sub-module covers information pertaining to the inspection task itself, including the levels of inspection, the terminology, the appearance of the defect, and the procedures for inspection (Figure 1.8).

Figure 1.8 The Sample Walkthrough Section of Inspection Procedure

Final Test

After completing all sub-modules, the inspector takes the Final Test at the end of the General Module (Figure 1.9). This test contains 20 multiple choice questions covering all the topics in the General Module. The results are stored in a database, which can be accessed by the instructor for later analysis.

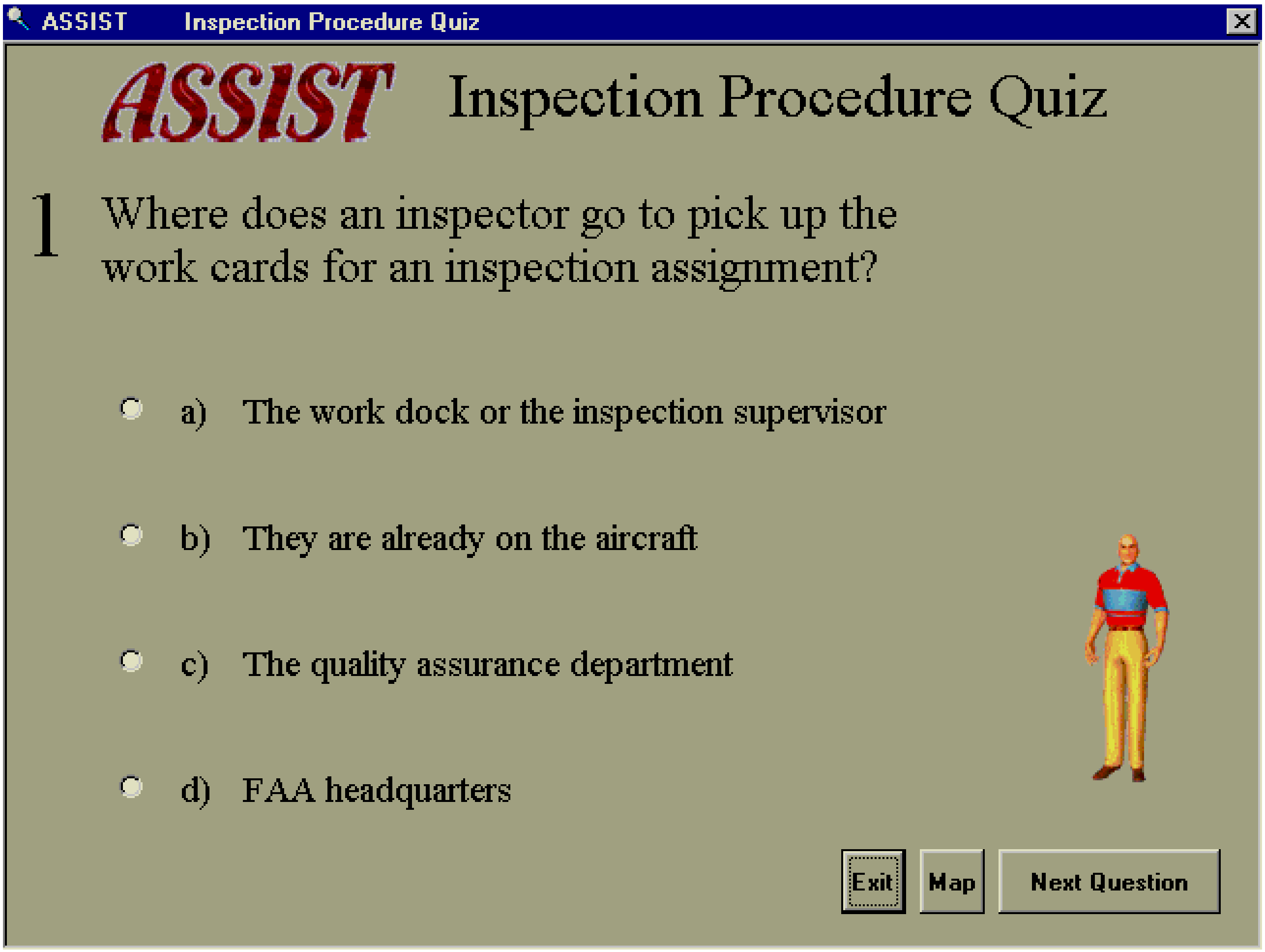

Figure 1.9 Sample Question from the Final Test of the General Module

Inspection Simulation Training Module

This module of the training program provides inspection training on a simulated aircraft inspection task: the Aft-Cargo bin inspection of a Lockheed Martin L-1011. By manipulating the various task complexity factors—the shape of the viewing area, the spatial distribution of faults, the fault probability, the fault mix, the fault conspicuity, the product complexity, the and fault standards--the instructor can simulate different inspection scenarios. The simulation module uses actual photographs of the airframe structure with computer-generated defects.

Introduction

The introduction provides the trainee with an overview of the various facets of the program, the work card for the inspection assignment, and a representation of various faults (Figure 1.10).

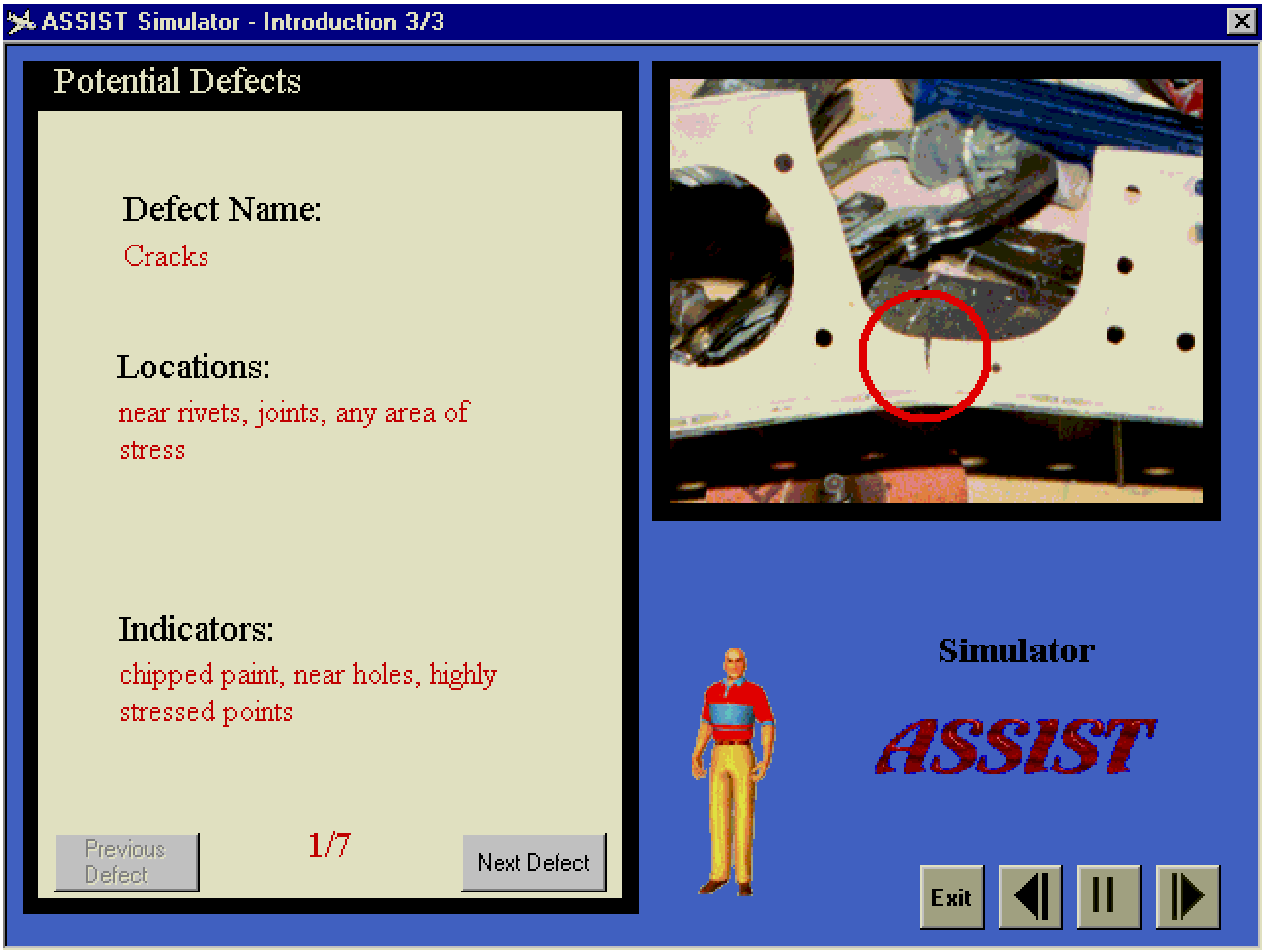

Figure 1.10 Potential Defects that may Occur in the Simulator

Testing

The testing module is designed to operate in two separate modes: with and without feedback, with the non-feedback mode simulating the actual visual inspection task as it would take place on a hangar floor. In either mode, the inspector first locates the defect and then indicates it by clicking on the fault. Subsequently, the inspector classifies the defect by filling out a Non-routine Card. In feedback mode, the inspectors are provided with feedback on their performance on the search and decision-making components of the inspection task. The trainee is also provided with feedback at the end of the performance. The program also features paced and unpaced modes. The paced mode allows the inspection to continue for only a specified period of time, while the unpaced mode allows the inspection task to be unbounded by time. In the simulator, the inspector can use four inspection tools: scraping knife, magnifying glass, mirror, and flashlight (Figure 1.11). These tools appropriately change the inspection image and potentially reveal defects that would not be seen by the unaided eye.

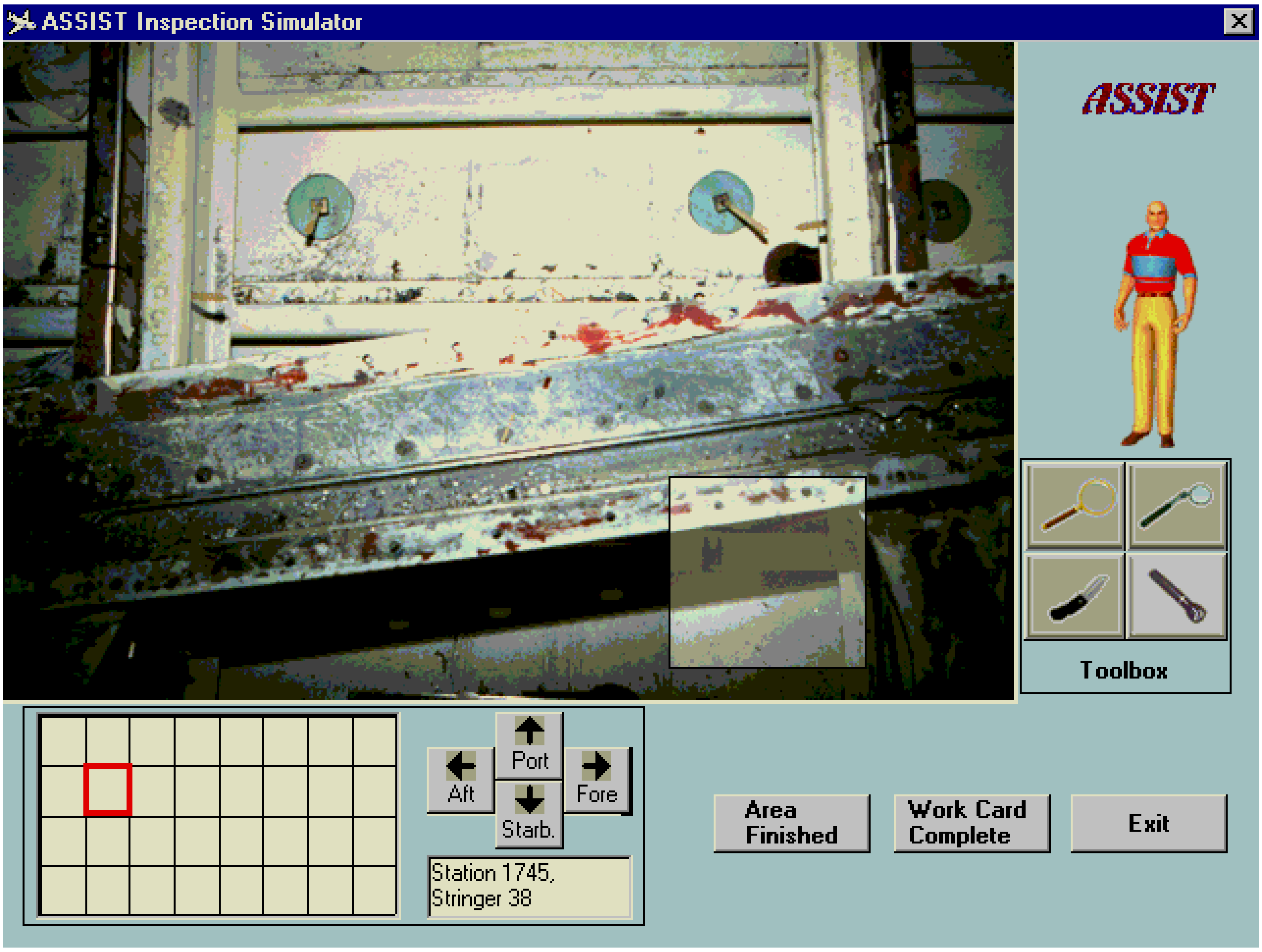

Figure 1.11 Using the Flashlight in the ASSIST Inspection Simulator

The Instructor's Utilities Module

The module is designed as a separate, stand-alone tool that is linked to the other modules of the system. It gives the instructors access to the results of the final test in the general module and the simulator allowing them to review the performance of a trainee who has taken several training and/or testing sessions (Figure 1.12). The module is designed as a separate stand-alone tool that is linked to the other modules of the system. Performance data from the simulator is stored on an individual image basis and summarized over the entire session so that results can be retrieved at either level. The utility allows the instructor to print or save the results to a file, thus providing the instructor with a utility where a specific image along with its associated information can be viewed on the computer screen.

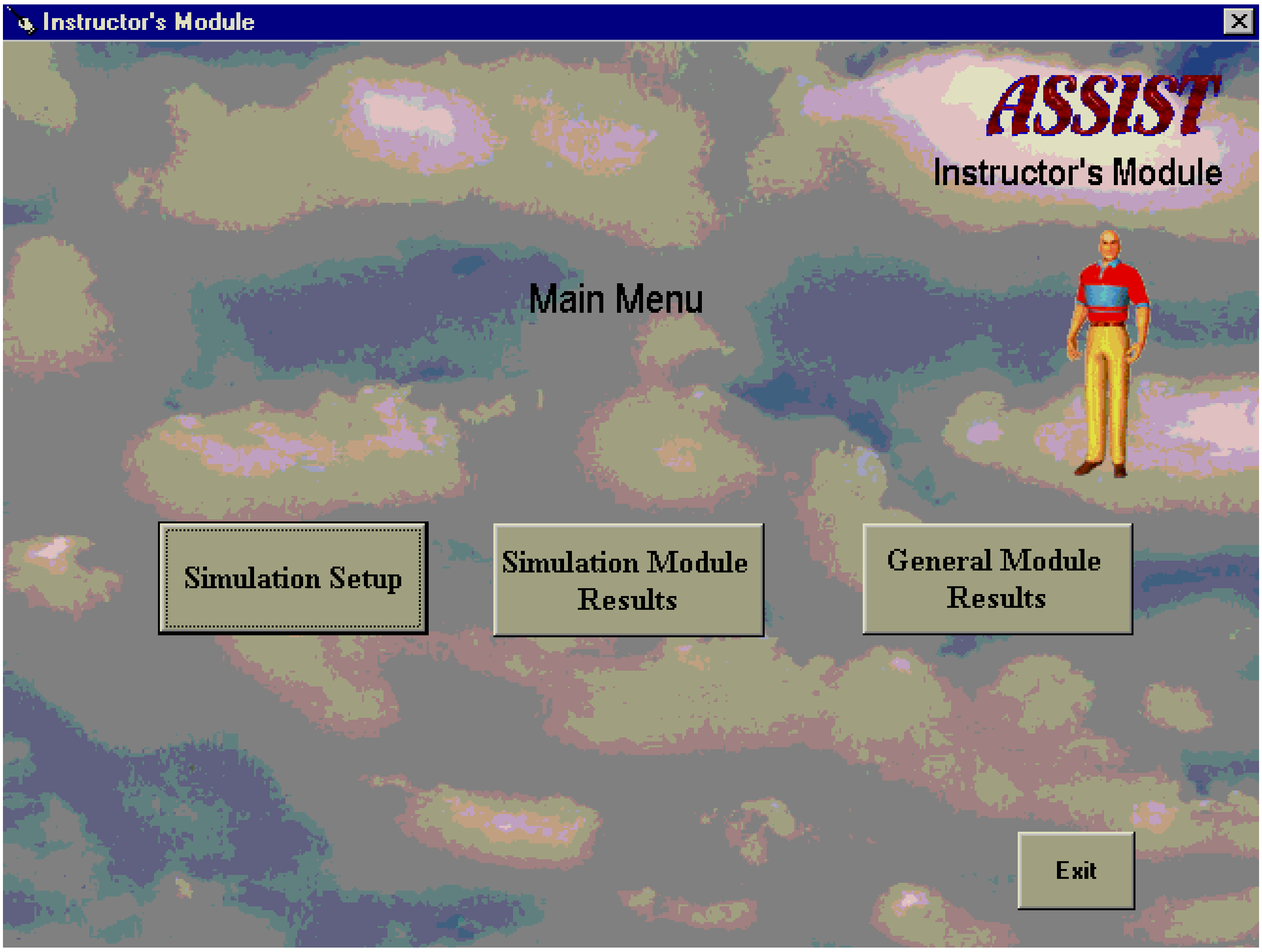

Figure 1.12 Main Menu of the Instructor's Module

In addition, this module has a simulation setup utility, allowing instructor to create different inspection scenarios by manipulating the inspection parameters (Figure 1.13). This utility allows the instructor to change the probability of defects, the defect mix, the complexity of the inspection task, and information provided in the work card, thereby varying the feedforward information provided. In addition, the inspector can chose the feedback (Figure 1.14) or non feedback mode and the pacing of the inspection.

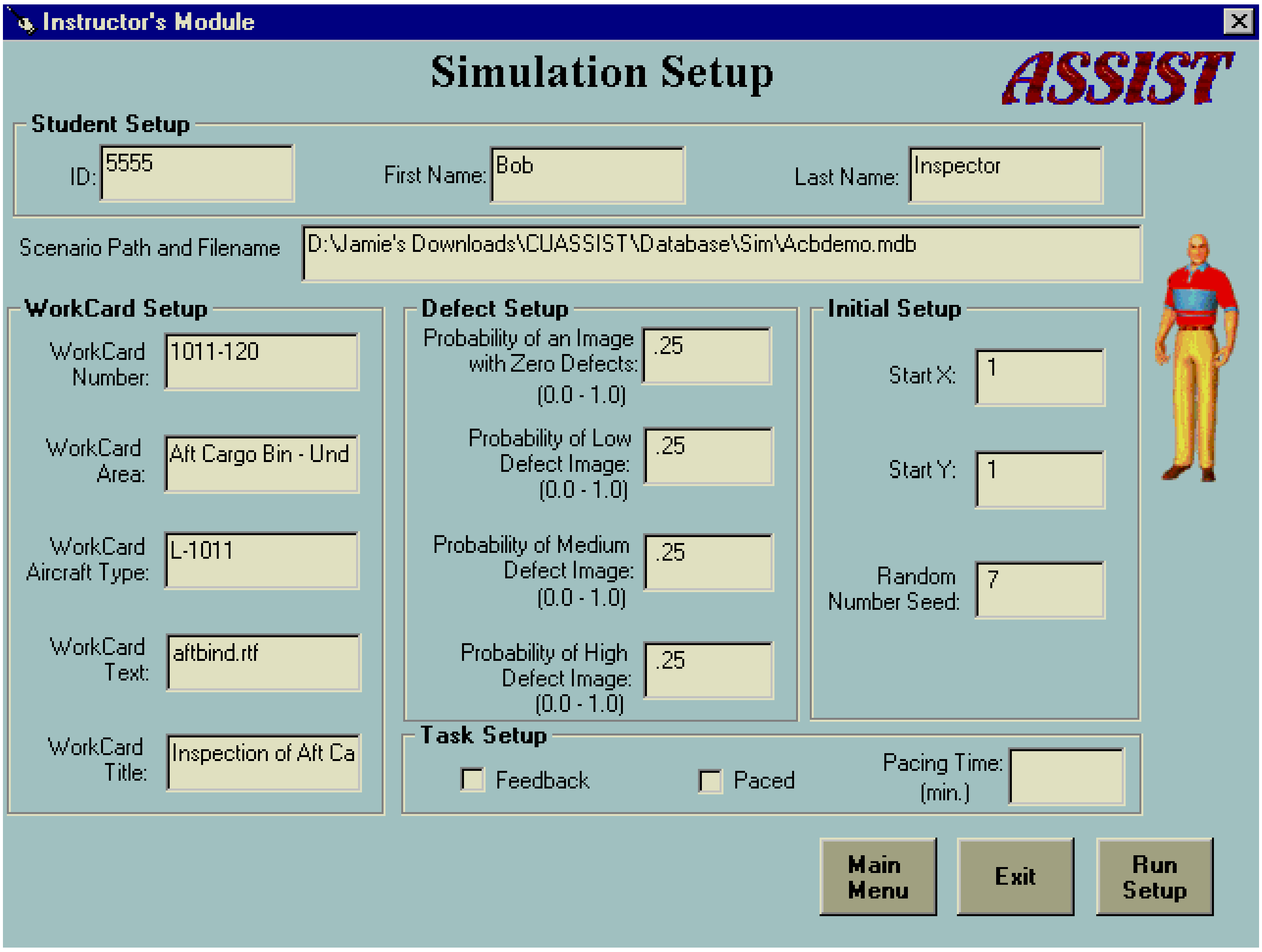

Figure 1.13 Simulator Setup Utility

Figure 1.14 Feedback Information Given by the ASSIST Program

Inspection Training Session

The training program was designed to use the general principles listed earlier in the context of this particular inspection job as derived by the task analysis. A major prerequisite was that it be a progressive part training scheme to enable the inspectors to build their repertoire of knowledge and skills in an orderly manner. A typical training session proceeded as follows:

1. Initial Overview: Initially, the subjects used the introduction module, wherein they were introduced to the navigation map and familiarized with the operational aspects of the computer program.

2. General Module Training: In the general module the subjects were provided with information on the following five topics: the role of the inspector, safety, aircraft review, the factors affecting inspection, and the inspection procedures. Using the navigation map, the subjects either directly went to a particular topic or sub-topic or followed the default path through the topics. At the end of each topic, a brief quiz was administered to review the subject's understanding of the material. The subjects were provided with feedback and correct answers. On completion of the topics in the general module, the subjects took the final test, consisting of questions selected from a database covering material from each topic within the general module.

3. Simulation Module: In the simulation module, subjects were initially introduced to the workings of the simulator. Following this step, the subjects were presented with a work card containing the instructions for the inspection assignment. Next, the subjects were provided with information on defect standards, including images of the defects, descriptions, likely locations for particular defects, and possible indicators. Following this step, the subjects conducted the inspection

using representative images of airframe structures wherein they had first search for the defect and later classify it as one necessitating maintenance action or not. The simulator allowed the use of various inspection tools: a mirror, flashlight, scraping knife, and magnifying glass to assist the subject in performing the inspection (Figure 1.11). Following the inspection, subjects completed a non-routine card (Figure 1.15). On completion of the task, subjects were provided with feedback on their overall performance in regard to the subject's search and decision-making performance, for example, the time to complete inspection, the defect detection, and the defect classification performance. The simulator can be operated in various modes (e.g., with or without feedback, paced or unpaced) and it allows the instructor to set various inspection parameters (e.g., the mix of defects, the defect probability and the workcard instructions), thereby facilitating the creation of different inspection scenarios.

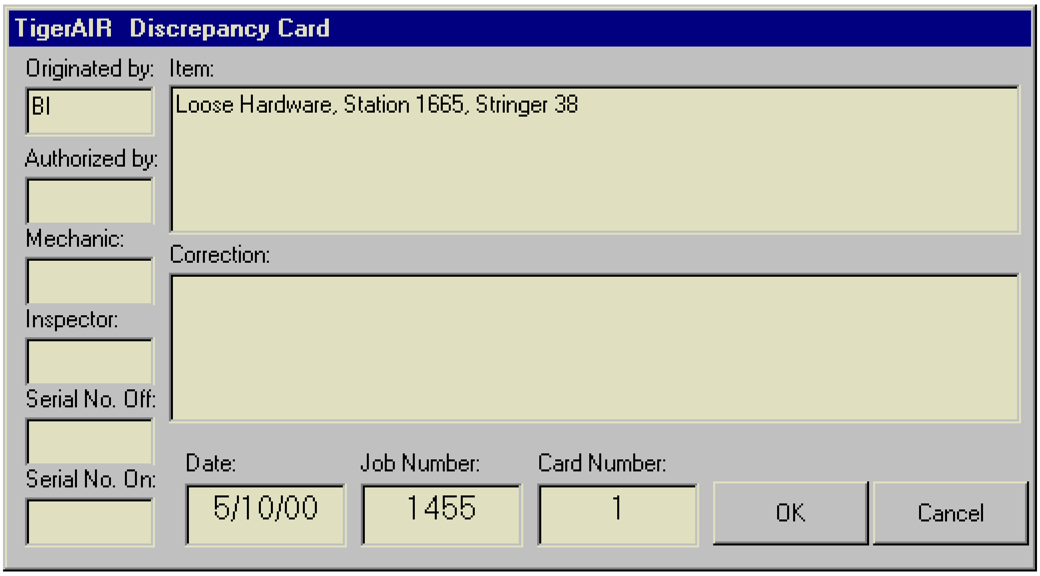

Figure 1.15 Non-routine Card Used to Record an Identified Defect

1.4 EVALUATION OF ASSIST

The development of ASSIST software demonstrates the application and the use of advanced technology for aircraft inspection training. Following the development, a detailed evaluation was conducted to determine the effectiveness of its use. The objectives of this evaluation were two-fold:

1. To evaluate the effectiveness of using computer-based aircraft inspection training, specifically the ASSIST system, in improving inspection performance, and

2. To conduct a detailed usability evaluation of the ASSIST software.

Accordingly, the study was divided into two parts, with Part I focusing on performance evaluation and Part 2 on usability evaluation. The methodologies supporting each part are described below.

1.5 METHODOLOGY

1.5.1 Subjects

The subjects for this study consisted of 18 inspectors from the team partner’s facilities who were paid their full hourly rate by the company for their participation. Those selected had different levels of inspection-related work experience (six subjects with less than one year of experience, six between one and 10 years, and six with more than 10 years of experience). The subjects were randomly assigned to one of the following two groups, the control group or the trained group, so that each had subjects with an equal distribution of work experience:

- Control Group: Subjects assigned to this group did not receive any inspection training.
- Trained Group: These subjects received training on both the general aspects of inspection as well as feedback training on a computer-simulated inspection task using the ASSIST software.

1.5.2 Experimental Design

The study used a mixed between and within subjects design. The training condition, training or no training, was the between subject factor whereas the pacing condition, paced or unpaced, was the within subjects factor (Table 1.3).

Equipment for Computer Simulation

The experiment was conducted using Hewlett Packard personal computers with a Windows NT Workstation 4.0 operating system and an Intel Pentium II processor operating at 300 Mhz. The subjects viewed the stimulus material at a resolution of 800x600 pixels/inch from 20 inches and responded to the stimulus material using a two-button mouse.

Stimulus Material

The stimulus material for the study consisted of the general and simulation modules of the ASSIST training program. This multimedia computer-based program developed to train aircraft inspectors on inspection skills was used to simulate the inspection tasks and to collect performance data.

Table 1.3 Assist Experiment Protocol

			Knowledge Test		ASSIST Training						
	Consent form	**Demographic survey**	**Section I: Short** Q & A	Section II: Multiple choice test	Simulation trial & demo	Simulation test		Training general	Training simulator	Simulator Test	
						Un-paced	Paced			Un-paced	Paced
Description of Protocol Stage		7 questions on topics such as age, experience, certification, and training	Short answer questions on General aircraft inspection	30 questions total (taken from the ASSIST software)	Parameter set: -No feedback (Small introduction to the ASSIST software and the simulated inspection environment)	Parameter set: 1st test- -Unpaced -No feedback 2nd test- -paced using mean of 1st test -No feedback		The ASSIST General Module (All five sub-modules)	Parameter set: 32 screen scenario- -Unpaced -Feedback	Parameter set: 1st test- -Unpaced -No feedback 2nd test- -Paced using mean of 1st test -No feedback	
9 subjects Trained	X	X	X	X	X	X		X	X	X	
9 subjects Control	X	X	X	X	X	X		N/A	N/A	X	

Procedure

At the outset all the subjects completed a consent form (Figure 1.16) and a demographics questionnaire (Figure 1.17) which solicited information on the subjects' backgrounds, ages and experience in inspection. Following this step, all subjects completed a two-section knowledge test with Section 1 consisting of short essay-type questions and Section II of multiple choice questions (Figures 1.18 through 1.20). Both sections of the test collected user information on the subjects' prior knowledge of aircraft inspection.

INFORMED CONSENT STATEMENT FOR AUTOMATED SELF-PACED SYSTEM FOR INSTRUCTIONAL SUPPORT AND TRAINING (ASSIST)

INFORMATION

You have been invited to participate in a research study entitled The ASSIST Evaluation Study. I participate, you will be one of eighteen subjects at your facility who will be participating in th participation will be on an individual basis.

Prior to any activities, you will be asked to fill out some personal demographic information. ALL IN WILL BE STRICTLY CONFIDENTIAL.

There are two distinct stages to this research. In the first stage, you will perform an on-the-job test a simulated test of aircraft inspection. You will then receive training from a computer-based multim training tutorial. In the second stage, you will perform another on-the-job test and another computer-s aircraft inspection.

You will also be asked to complete a multiple-choice test both before and after training. The scor will not be revealed to anyone other than yourself (upon request) and the investigators conducting

This study is not to measure your individual ability as an inspector, but rather to measure the effects method.

The terminology used throughout this research study is meant to be general in nature and not sp Air Lines. If you have questions on the terminology given, please see the training administra

ESTIMATED TIME FOR STAGE 1 and TRAINING = 4 HOURS

At the conclusion of the study you will be asked to fill out a questionnaire giving us your opinion of the

ESTIMATED TIME FOR STAGE 2 = 3 HOURS

CONSENT

I have been given the opportunity to ask questions about this study, answers to questions (if a satisfactory.

The information in the study records will be kept confidential and will be made available only to pers the study unless I specifically give permission in writing to do otherwise. In any results of this study tha I will not be identified.

In consideration of all of the above, I give my consent to participate in this research study. I understand out of this study at any point if I so choose.

I acknowledge receipt of a copy of this informed consent statement.

SIGNATURE OF SUBJECT

DATE______________________________

SIGNATURE OF WITNESS ____

SIGNATURE OF INVESTIGATOR ______________________________

Figure 1.16 Consent Form

Name ____

1. Sex ________Male ________Female

2. Age ________<20 ________21-30 ________31-40 ________41-50 ____

1. How long have you been an aircraft inspector?

________<1 yr. ________1-10 yrs. ________10 yrs. +

2. How long have you been in the aircraft maintenance industry?

<1 yr. 1-10 yrs. 10 yrs. +

3. What shift are you currently working?

________1st ________2nd ________3rd

4. Which of the following certificates/licenses do you have? (Select more than one if approp

________Airframe certificate ________Power Plant certificate

________Repairman certificate ________FCC license

Inspection authorization certificate

5. Where did you receive the majority of your technical training?

________Military ________Technical Schools ________Company training

6. Your primary job function as an inspector is:

______ HMV ______ Letter check

Figure 1.17 Demographic Survey

Knowledge Test Section I: Short Q & A

Scoring:

Correct Answer – all information and terminology given is correct and complete [score = 5]
Partially Correct Answer – information is incomplete or partially wrong [score = 3]
Wrong Answer – information given is wrong [score = 1]

1. What are two types of inspection?
2. What are two types of quality audits? Describe them?
3. What is parts control?
4. With regard to noise, what is masking?
5. What three things can affect the light available for visual inspection?
6. What is the difference between indirect and direct lighting?
7. What are four things you can do as an off-shift worker to combat fatigue?
8. Name two types of search strategies and define them. Which is better?
9. What are seven critical task factors that influence inspection performance?
10. List nine forms that written communication in the aircraft inspection industry m from?
11. What are five common errors in written communication?
12. Why is feedback important? What are the two forms of feedback?
13. What are two things you could do if you go to the area you are to inspect and you can't see very poor lighting?
14. Why is it sometimes necessary to perform buy-back inspection?

Figure 1.18 Knowledge Test Section I: Short Q & A

ASSIST EVALUATION: MULTIPLE CHOICE TEST (30 QUESTIONS): BEFORE TRAI

Question 1: Maintenance on an item has been completed, the area has been closed, and maintenance has sign
As a buy-back inspector you should:

Answer A: sign-off on the inspection.
Answer B: ask the mechanic to open up the area and inspect it and then sign off on it
inspection)
Answer C: ask another buy-back inspector in the field to sign-off on it.
Answer D: All of the above

Question 2: The common inspection tools include all of the following except:

Answer A: flashlight.
Answer B: steel scale.
Answer C: magnifying glass.
Answer D: screwdriver.

Question 3: When performing an OK to close inspection, always remember to:

Answer A: Take one last look for defects.
Answer B: Sign the work card.
Answer C: Make sure all tools have been picked up.
Answer D: All of the above.

Question 4: Which of the following tasks relate to the scope of the inspector's job:

Answer A: Providing explanation if the mechanic performs an incorrect installation or repai
Answer B: Inspecting the aircraft and not performing the mechanic's work.
Answer C: Answering any questions about the Non-Routine card.
Answer D: All of the above.

Question 5: Your actions while inspecting an aircraft can affect which of the following:

Answer A: You
Answer B: Your fellow employees
Answer C: The airworthiness of the aircraft
Answer D: All of the above

Question 6: When attempting to inspect inside a poorly lighted bag bin:

Answer A: Do not be concerned, there is probably enough light to see your way.
Answer B: Keep all the doors open so light from the hangar can enter.
Answer C: Bring more fixed lighting equipment inside the bag bin.
Answer D: Just use your flashlight to see.

Question 7: Being very familiar with emergency equipment in your area will:

Answer A: help you quickly resolve an emergency situation.
Answer B: let you escape a dangerous area.
Answer C: provide a safe place during emergencies.
Answer D: All of the above

Question 8: What is the biggest danger of foreign object damage (FOD)?

Answer A: Danger to the hangar.
Answer B: Loss of a tool.

ASSIST EVALUATION: MULTIPLE CHOICE TEST (30 QUESTIONS): BEFORE TRAI

Question 1:	Maintenance on an item has been completed, the area has been closed, and maintenance has sign As a buy-back inspector you should:
Answer A:	sign-off on the inspection.
Answer B:	ask the mechanic to open up the area and inspect it and then sign off on it inspection)
Answer C:	ask another buy-back inspector in the field to sign-off on it.
Answer D:	All of the above
Question 2:	The common inspection tools include all of the following except:
Answer A:	flashlight.
Answer B:	steel scale.
Answer C:	magnifying glass.
Answer D:	screwdriver.
Question 3:	When performing an OK to close inspection, always remember to:
Answer A:	Take one last look for defects.
Answer B:	Sign the work card.
Answer C:	Make sure all tools have been picked up.
Answer D:	All of the above.
Question 4:	Which of the following tasks relate to the scope of the inspector's job:
Answer A:	Providing explanation if the mechanic performs an incorrect installation or repai
Answer B:	Inspecting the aircraft and not performing the mechanic's work.
Answer C:	Answering any questions about the Non-Routine card.
Answer D:	All of the above.
Question 5:	Your actions while inspecting an aircraft can affect which of the following:
Answer A:	You
Answer B:	Your fellow employees
Answer C:	The airworthiness of the aircraft
Answer D:	All of the above
Question 6:	When attempting to inspect inside a poorly lighted bag bin:
Answer A:	Do not be concerned, there is probably enough light to see your way.
Answer B:	Keep all the doors open so light from the hangar can enter.
Answer C:	Bring more fixed lighting equipment inside the bag bin.
Answer D:	Just use your flashlight to see.

Figure 1.19a Knowledge

Question 7:	Being very familiar with emergency equipment in your area will:
Answer A:	help you quickly resolve an emergency situation.
Answer B:	let you escape a dangerous area.
Answer C:	provide a safe place during emergencies.
Answer D:	All of the above
Question 8:	What is the biggest danger of foreign object damage (FOD)?
Answer A:	Danger to the hangar.
Answer B:	Loss of a tool.
Answer C:	Damage to the aircraft.
Answer D:	None of the above.
Question 9:	Which is a long-range 4 engine aircraft?
Answer A:	737
Answer B:	747
Answer C:	757/767
Answer D:	777
Question 10:	Which aircraft would be least likely to have a large number of defects based on years in service?
Answer A:	MD-90
Answer B:	L-1011
Answer C:	747
Answer D:	A300
Question 11:	_____ is the ability to see detail at various distances from the object of regard.
Answer A.	Color vision
Answer B.	Visual acuity
Answer C.	Peripheral vision
Answer D.	Conspicuity
Question 12:	Factor(s) that make up an inspector's physical environment is (are):
Answer A.	Amount of lighting.
Answer B.	Work design
Answer C.	Ambient temperature and humidity level.
Answer D.	Both A and C
Question 13:	Experience can be categorized based on:
Answer A.	Number of years of work
Answer B.	Variety of work conducted
Answer C.	Both A and B
Answer D.	None of the above

Figure 1.19b Knowledge

Question 14: Given a fixed time period, strategies to maintain accuracy when time is limited are:

Answer A. Add more inspectors
Answer B. Incorporate a systematic search strategy
Answer C. Both A and B
Answer D. None of the above

Question 15: In order for an inspector to properly perform an inspection, the inspector:

Answer A. Must have the correct equipment and tools available.
Answer B. Must have access to the required documentation and manuals.
Answer C. Must be trained on the proper use of the equipment and tools.
Answer D. All of the above

Question 16: Process factors refer to:

Answer A. Elements of the inspection process that may either help or hinder an inspector fr his/her job.
Answer B. Organizational requirements by an inspector's employer.
Answer C. Factors regarding the communication of information.
Answer D. Factors that make up an inspector's physical environment.

Question 17: Where is the Aircraft Logbook kept?

Answer A: At the service facility that would use it the most
Answer B: Each service facility has a copy
Answer C: With the aircraft both in-flight and during service
Answer D: At FAA Headquarters

Question 18: Where does an inspector go to pick up the work cards for an inspection assignment?

Answer A: The work dock or the inspection supervisor
Answer B: They are already on the aircraft
Answer C: The quality assurance department
Answer D: FAA Headquarters

Question 19: Which type of inspection would be best suited for viewing the inside of an engine during an engi

Answer A: Visual
Answer B: Borescope
Answer C: X-Ray
Answer D: Coin Tap

Figure 1.19c Knowledge

Question 20: A check to see whether a unit or system performs within specified limits is called what?

Answer A: Final Inspection
Answer B: Functional Check
Answer C: Missed Item
Answer D: Required Inspection Item (RII)

Question 21: In addition to being familiar with all inspection methods, techniques, and equipment in their specialty, aircraft inspectors must:

Answer A: maintain proficiency in using various inspection aids intended for that purpose.
Answer B: have available and understand current specifications involving inspection tolerance limitations, and procedures established by the manufacturer of the product beir inspected and with other information such as FAR's.
Answer C: in cases where mechanical inspection devices are to be used, be skilled in operatir that equipment and be able to properly interpret indications.
Answer D: All of the above.

Question 22: Buy-back inspection steps include all of the following except:

Answer A: Signing off on a workcard if satisfied.
Answer B: Helping the mechanic complete his or her work.
Answer C: A mechanic requesting an inspection.
Answer D: Inspecting the work done by the mechanic.

Question 23: When in doubt about a procedure for safety reasons, you should:

Answer A: Use your own judgement.
Answer B: Consult the company safety manual.
Answer C: Consult Airworthiness Directives.
Answer D: Consult other inspectors in the area.

Question 24: For effective hearing protection, you should:

Answer A: Know the blast and suction zones around a particular aircraft.
Answer B: Wear earplugs or "earmuffs."
Answer C: Work frequently near the use of a pneumatic rivet gun.
Answer D: All of the above

Question 25: Which Airbus aircraft is an ultra-long range 4-engine model?

Answer A: A300
Answer B: A320
Answer C: A330
Answer D: A340

Figure 1.19d Knowledge

Question 26: Written communication in the aircraft inspection industry may come in the form of:

Answer A. Workcards, non-routine cards, and bulletins.
Answer B. Manufacturer's manuals, OSHA guidelines, and advisory circulars.
Answer C. FAR's, AD's, and company procedures.
Answer D. All of the above

Question 27: _____ may lead to lowering of quality and performance, loss of time and money, and frustration.

Answer A. Work design
Answer B. Improper communication
Answer C. Teamwork
Answer D. Lighting

Question 28: Because of the depth of knowledge and skills required for aviation inspection and maintenance tasks, a heavy emphasis must be placed upon _____.

Answer A. Job design
Answer B. Work design
Answer C. Workplace design
Answer D. Training

Question 29: Which of the following is NOT considered to be a type of Non-Destructive Inspection (NDT)?

Answer A: Eddy Current
Answer B: Dye-Penetrant
Answer C: Visual Inspection
Answer D: Coin Tap

Question 30: Which of these documents would you expect to have information about a widely known problem on an aircraft?

Answer A: Significant Structural Item (SSI)
Answer B: Federal Aviation Regulations (FAR)
Answer C: Inspection work dock
Answer D: Discrepancy Report

Figure 1.19e Knowledge

ASSIST EVALUATION: MULTIPLE CHOICE TEST (30 QUESTIONS): AFTER TRAI

Question 1: Maintenance on an item has been completed, the area has been closed, and maintenance l signed off on it. As a buy-back inspector you should:

Answer A: sign-off on the inspection.
Answer B: ask the mechanic to open up the area and inspect it and then sign off on it on inspection)
Answer C: ask another buy-back inspector in the field to sign-off on it.
Answer D: All of the above

Question 2: The common inspection tools include all of the following except:

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Answer C: magnifying glass.
Answer D: screwdriver.

Question 3: When performing an OK to close inspection, always remember to:

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Answer B: Inspecting the aircraft and not performing the mechanic's work.
Answer C: Answering any questions about the Non-Routine card.
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Question 5: Your actions while inspecting an aircraft can affect which of the following:

Answer A: You
Answer B: Your fellow employees
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Answer D: All of the above

Question 6: When attempting to inspect inside a poorly lighted bag bin:

Answer A: Do not be concerned, there is probably enough light to see your way.
Answer B: Keep all the doors open so light from the hangar can enter.
Answer C: Bring more fixed lighting equipment inside the bag bin.
Answer D: Just use your flashlight to see.

Figure 1.20a Knowledge Test Section II : Multiple Choice Test

Question 7: Being very familiar with emergency equipment in your area will:

Answer A: help you quickly resolve an emergency situation.
Answer B: let you escape a dangerous area.
Answer C: provide a safe place during emergencies.
Answer D: All of the above

Question 8: What is the biggest danger of foreign object damage (FOD)?

Answer A: Danger to the hangar.
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Answer C: Damage to the aircraft.
Answer D: None of the above.

Question 9: Which is a long-range 4 engine aircraft?

Answer A: 737
Answer B: 747
Answer C: 757/767
Answer D: 777

Question 10: Which aircraft would be least likely to have a large number of defects based on years in s

Answer A: MD-90
Answer B: L-1011
Answer C: 747
Answer D: A300

Question 11: _____ is the ability to see detail at various distances from the object of regard.

Answer A. Color vision
Answer B. Visual acuity
Answer C. Peripheral vision
Answer D. Conspicuity

Question 12: Factor(s) that make up an inspector's physical environment is (are):

Answer A. Amount of lighting.
Answer B. Work design
Answer C. Ambient temperature and humidity level.
Answer D. Both A and C

Question 13: Experience can be categorized based on:

Answer A. Number of years of work
Answer B. Variety of work conducted
Answer C. Both A and B
Answer D. None of the above

Figure 1.20b Knowledge Test Section II : Multiple Choice Test

Question 14: Given a fixed time period, strategies to maintain accuracy when time is limited are:

Answer A. Add more inspectors
Answer B. Incorporate a systematic search strategy
Answer C. Both A and B
Answer D. None of the above

Question 15: In order for an inspector to properly perform an inspection, the inspector:

Answer A. Must have the correct equipment and tools available.
Answer B. Must have access to the required documentation and manuals.
Answer C. Must be trained on the proper use of the equipment and tools.
Answer D. All of the above

Question 16: Process factors refer to:

Answer A. Elements of the inspection process that may either help or hinder an inspect
doing his/her job.
Answer B. Organizational requirements by an inspector's employer.
Answer C. Factors regarding the communication of information.
Answer D. Factors that make up an inspector's physical environment.

Question 17: Where is the Aircraft Logbook kept?

Answer A: At the service facility that would use it the most
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Answer C: With the aircraft both in-flight and during service
Answer D: At FAA Headquarters

Question 18: Where does an inspector go to pick up the work cards for an inspection assignment?

Answer A: The work dock or the inspection supervisor
Answer B: They are already on the aircraft
Answer C: The quality assurance department
Answer D: FAA Headquarters

Question 19: Which type of inspection would be best suited for viewing the inside of an engine during engine check?

Answer A: Visual
Answer B: Borescope
Answer C: x-ray
Answer D: Coin Tap

Figure Figure 1.20c Knowledge Test Section II : Multiple Choice Test

Question 20: A check to see whether a unit or system performs within specified limits is called what?

Answer A: Final Inspection
Answer B: Functional Check
Answer C: Missed Item
Answer D: Required Inspection Item (RII)

Question 21: Initial inspection

Answer A: is performed in order to find any damage after normal use of the aircraft.
Answer B: includes receipt of a work card, locating the designated area on the searching for defects, showing the defects to mechanics.
Answer C: Both A and B.
Answer D: None of the above

Question 22: During an engine run, you should be most concerned about:

Answer A: Personnel and equipment near the aircraft.
Answer B: Taxiing the aircraft to the test area.
Answer C: Running the engines at test speeds.
Answer D: None of the above

Question 23: When attempting to access an aircraft for inspection, remember to:

Answer A: Not worry about how old or unstable a ladder looks, just use it.
Answer B: Find a stable platform to climb and enter the aircraft.
Answer C: Drive the mobile lifts as close as possible to the aircraft.
Answer D: None of these.

Question 24: Which aircraft are tri-jets?

Answer A: L-1011
Answer B: MD-11
Answer C: 777
Answer D: A and B

Question 25: The two types of lighting are:

Answer A. Stroboscopic and black.
Answer B. Black and white.
Answer C. Direct and indirect.
Answer D. Direct and stroboscopic.

Figure 1.20d Knowledge Test Section II : Multiple Choice Test

Question 26: Which statement(s) is(are) true about masking.

Answer A. Masking can result in hearing loss.
Answer B. Masking is a condition in which one component of the sound envi reduces sensitivity of the ear to another component.
Answer C. An example of masking is the sound of a rivet gun going off which dro sound of the back up alarm on a truck or cherry picker.
Answer D. Both B and C

Question 27: Teams in the aircraft inspection and maintenance environment:

Answer A. Share common goals.
Answer B. Require cooperation and communication.
Answer C. Have more pride in their work.
Answer D. All of the above

Question 28: On average, how often does a plane come in for a layover check?

Answer A: Every 4 years
Answer B: Every 12-13 months
Answer C: Every 3 months
Answer D: Every 3-5 days

Question 29: With variation by fleet, on average, how often does a plane come in for a service check?

Answer A: Every 4 years
Answer B: About 12-13 months
Answer C: About every month
Answer D: Every night

Question 30: What document is used to record defects found during inspection in the hangar?

Answer A: A work card
Answer B: A discrepancy report (non-routine card)
Answer C: A significant structural item (SSI)
Answer D: The aircraft logbook

Figure 1.20e Knowledge Test Section II : Multiple Choice Test

Following this step, subjects in the both the Control and Training Groups were provided with an orientation on the ASSIST software. Upon completion of the orientation, only the subjects in the training group received inspection training through the general and simulation training modules of the ASSIST software. The general training module consisting of various sub-modules focused on the following topics: Role of Inspector, Safety, Aircraft Review, Factors Affecting Inspection and Inspection Procedure (Figure 1.21). After completion of each sub-module, the subjects' knowledge of the material was tested through a short Q and A session with subjects being provided with immediate feedback on their performance and correct answers being supplied to incorrect responses (Figure 1.22).

Figure 1. 21 Screen Shot from Factors Affecting Inspection in ASSIST

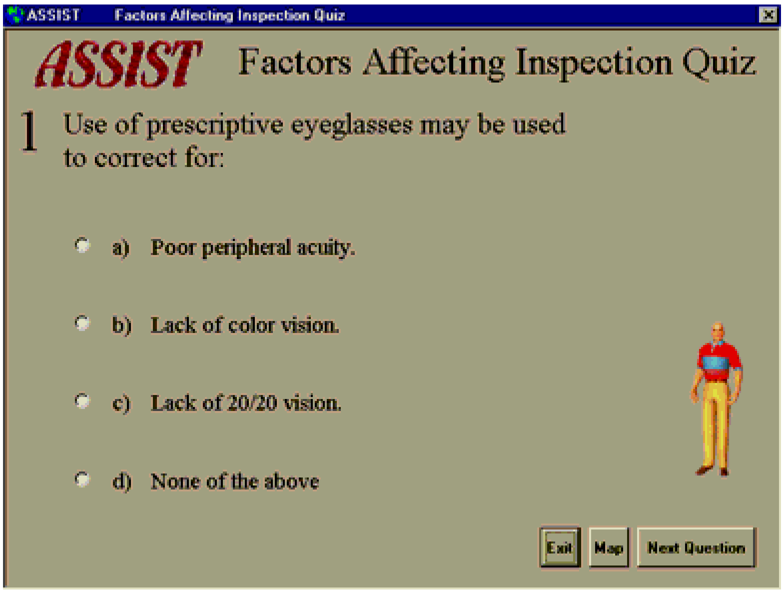

Figure 1.22 Sample Question from a Final Test

In the simulation training portion, subjects were provided inspection training on the computer-simulated aircraft inspection task (Figures 1.23 through 1.29). Subjects were tasked with completing the inspection of the Aft-Cargo bin of an L-1011. Initially, subjects were provided with a work card -- work instructions identifying the inspection task to be completed (Figure 1.30). Following this step the subjects were presented with a series of photographic images that constituted a portion of the Aft-Cargo bin of an L-1011 aircraft (Figure 1.31). Each photographic image displayed on the computer screen consisted of a single search area. Subjects could navigate from one area to the next by using the "navigational –aid" provided in the software. As each area was displayed, subjects visually searched the area for defects and reported their identification by clicking the mouse on them. Subjects could use four separate tools – a mirror, flashlight, magnifying glass and paint scraper--to aid them in their search. Upon identification of the defects, subjects completed a non-routine card similar to the one they would complete during the actual inspection in the hangar (Figure 1.32). In the training mode, subjects were provided with immediate feedback on their performance following the inspection of each search area, including feedback on missed defects, false alarms (areas incorrectly identified as having defects), the time to complete inspection and the correctly completed non-routine card (Figure 1.33).

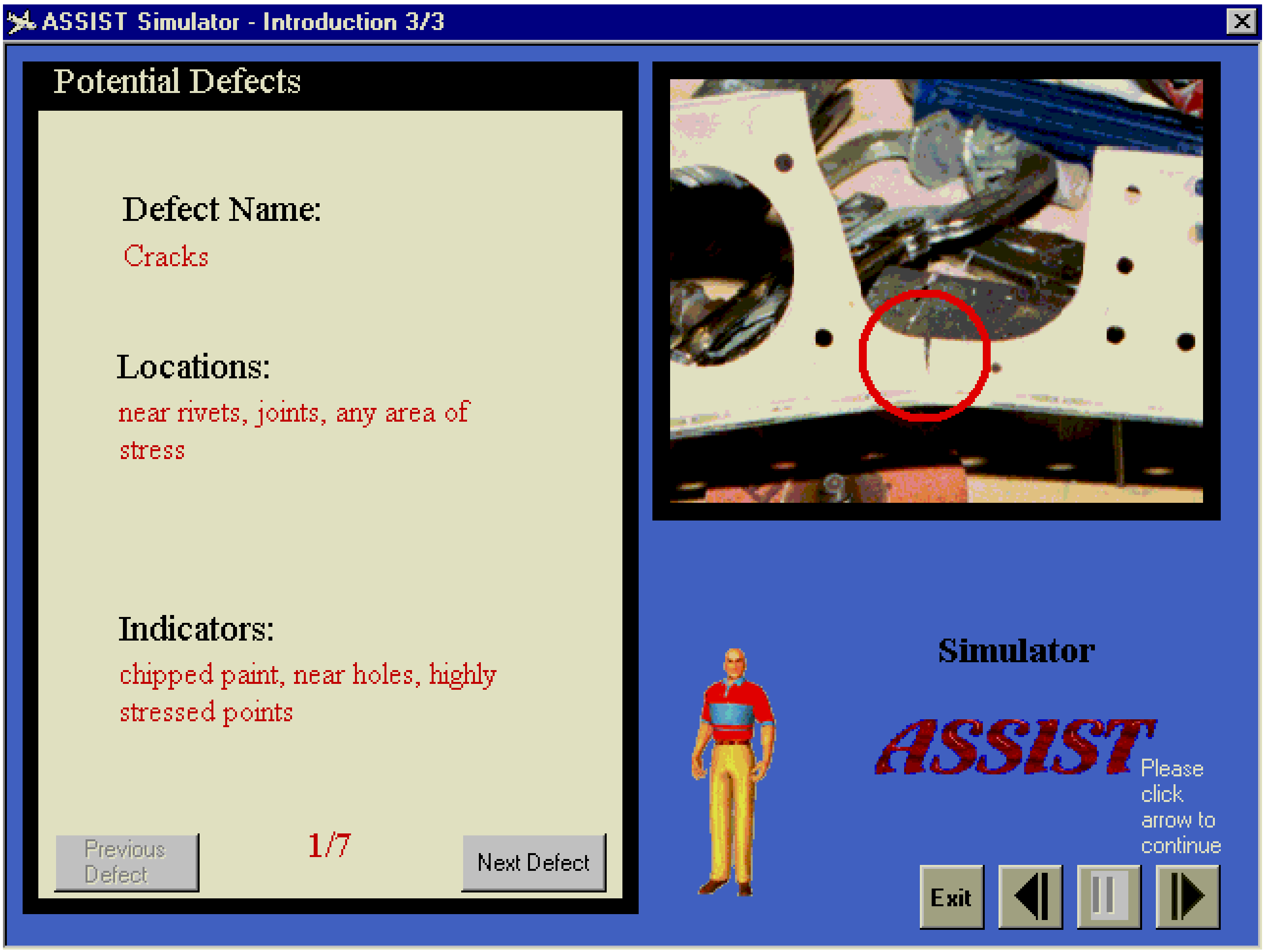

Figure 1.23 The Crack Defect Simulated in ASSIST

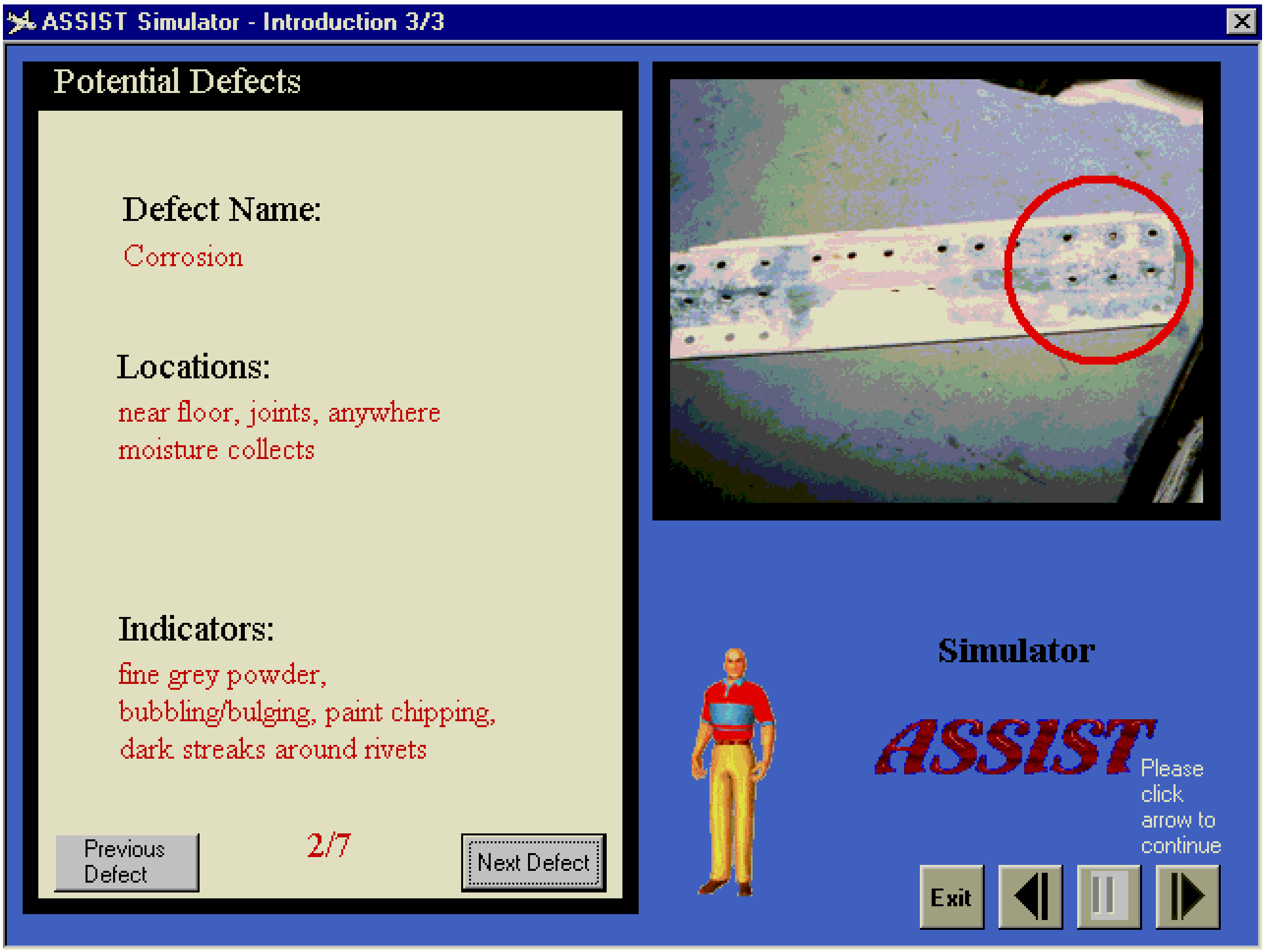

Figure 1.24 The Corrosion Defect Simulated in ASSIST

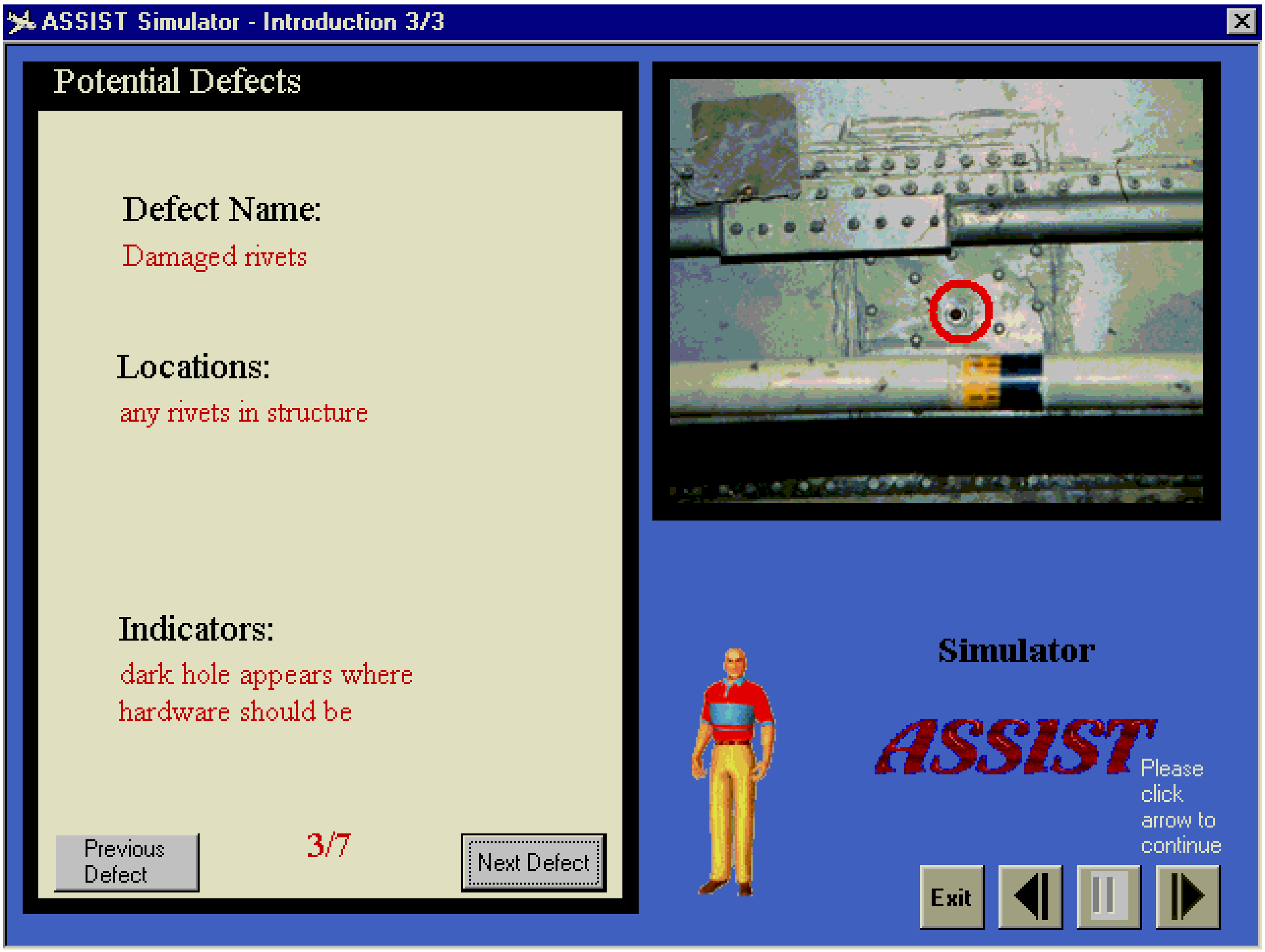

Figure 1.25 The Damaged Rivet Defect Simulated in ASSIST

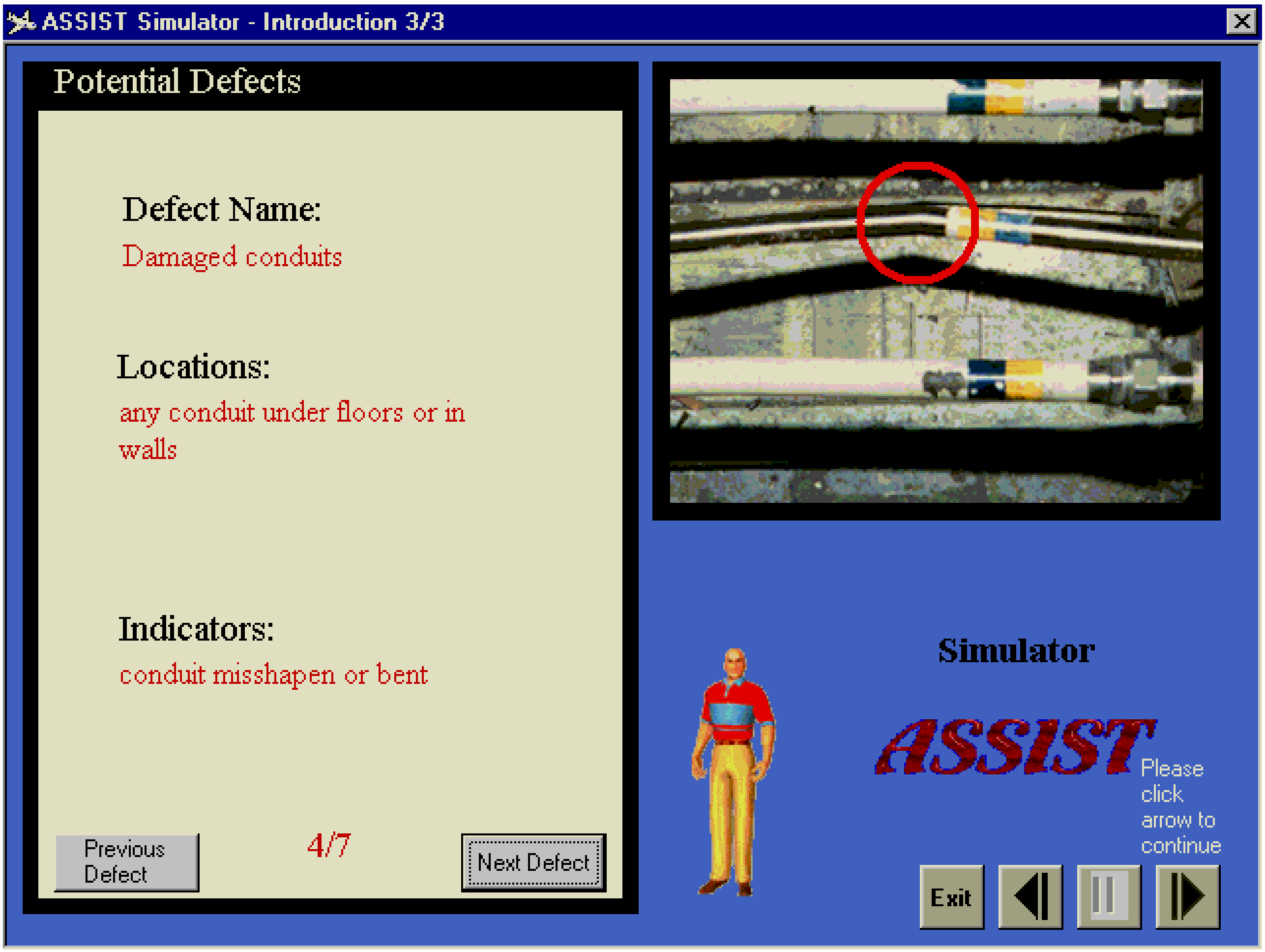

Figure 1.26 The Damaged Conduit Defect Simulated in ASSIST

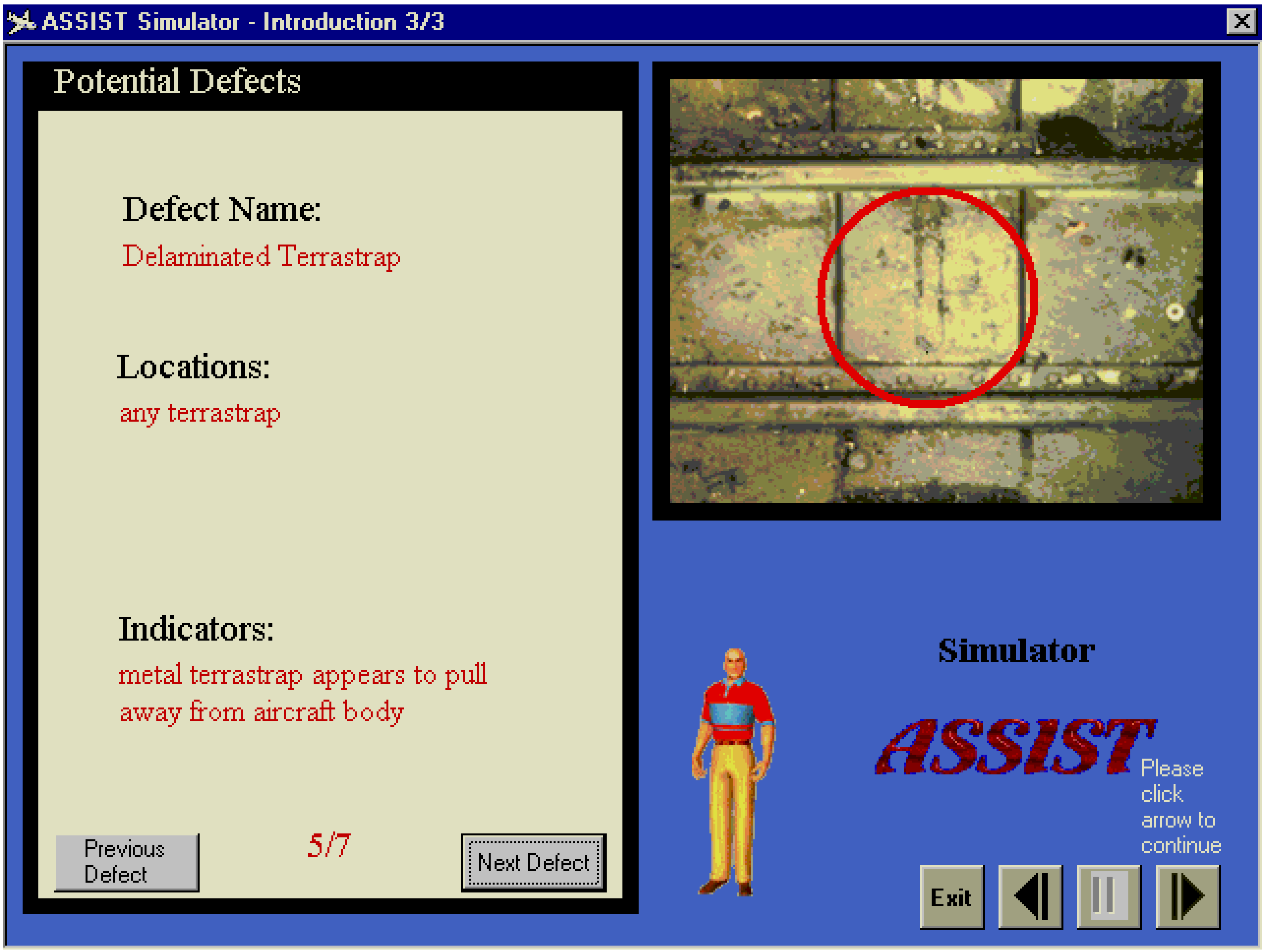

Figure 1.27 The Delaminated Terrastrap Defect Simulated in ASSIST

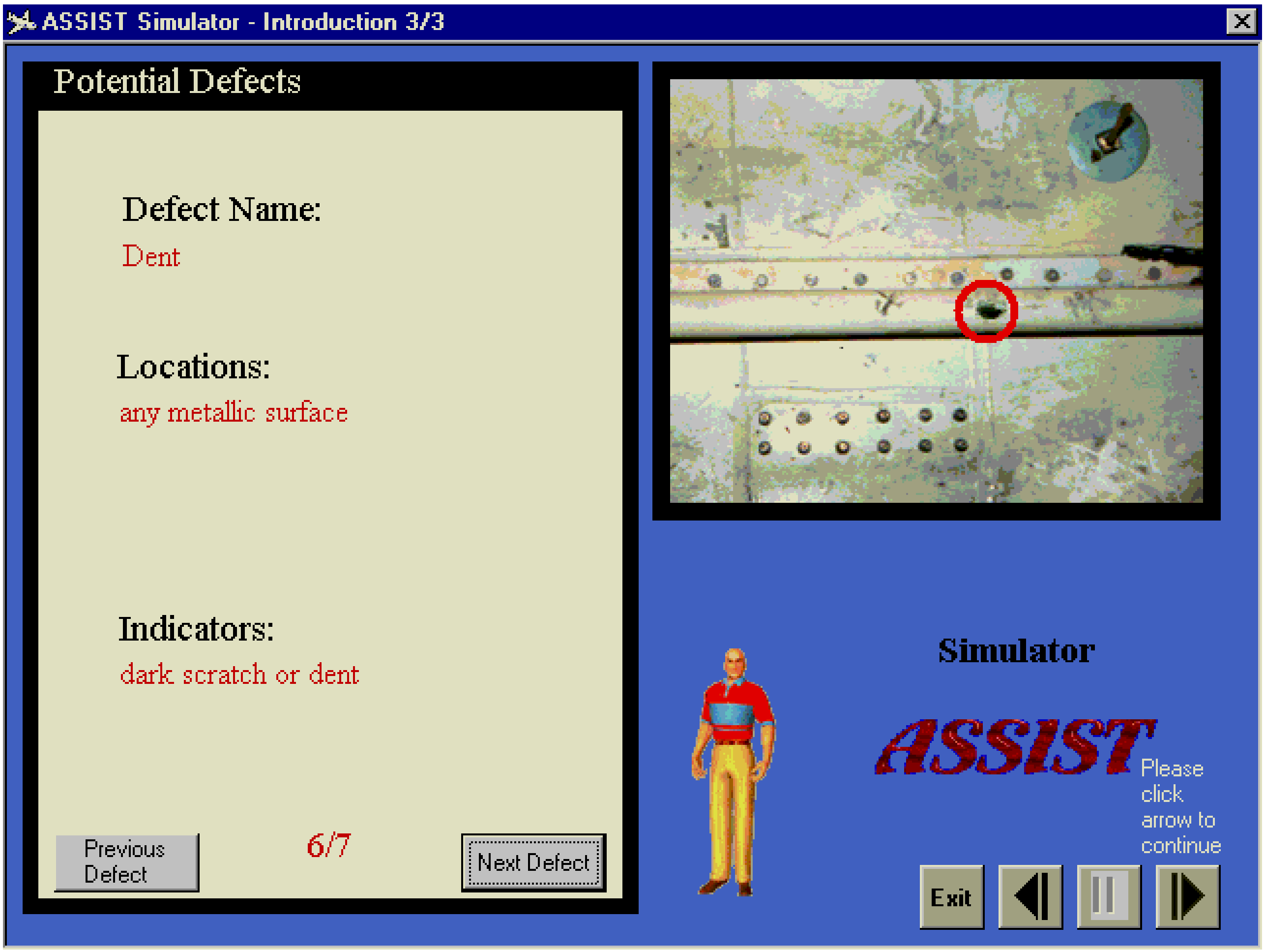

Figure 1.28 The Dent Defect Simulated in ASSIST

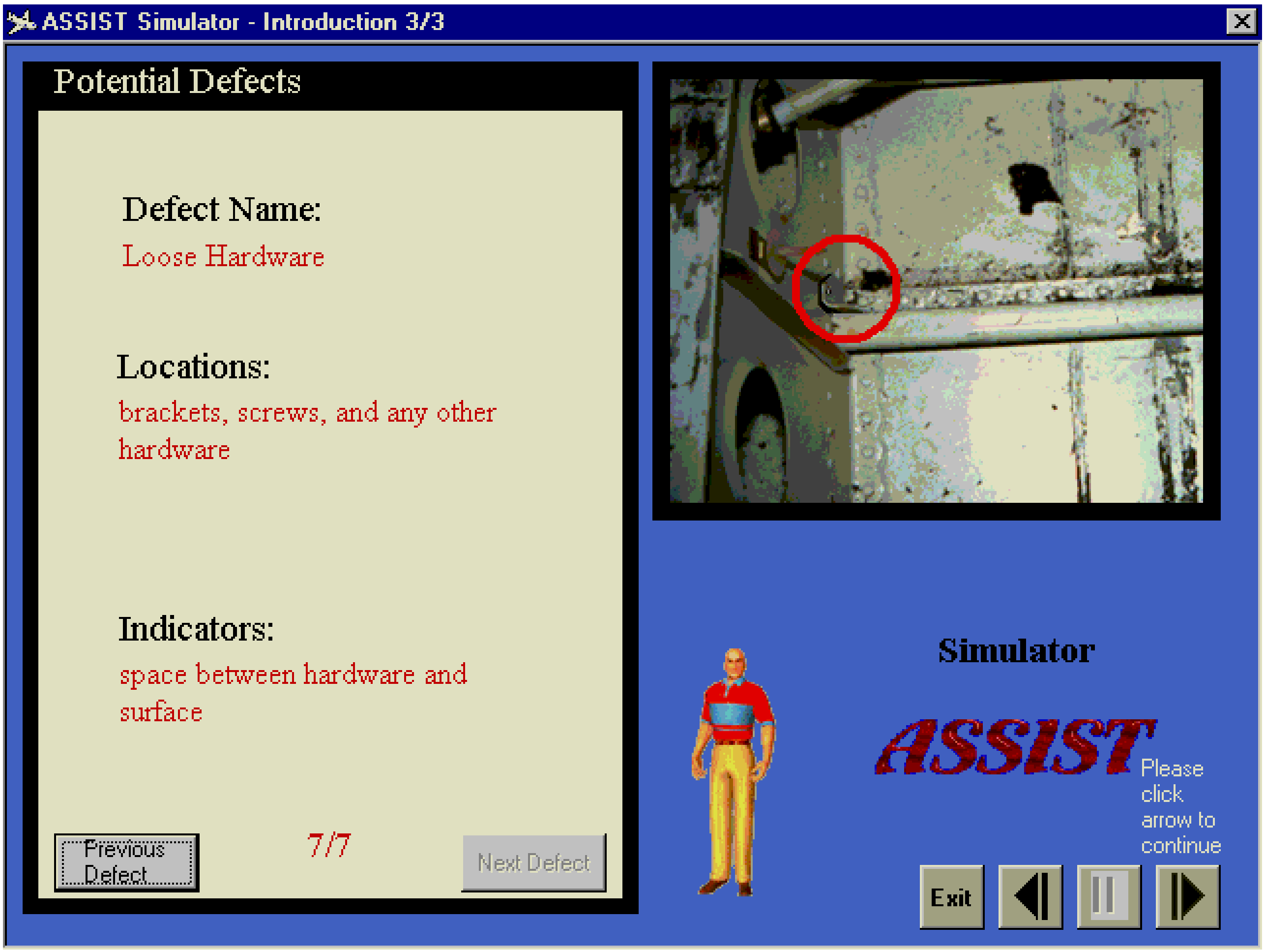

Figure 1.29 The Loose Hardware Defect Simulated in ASSIST

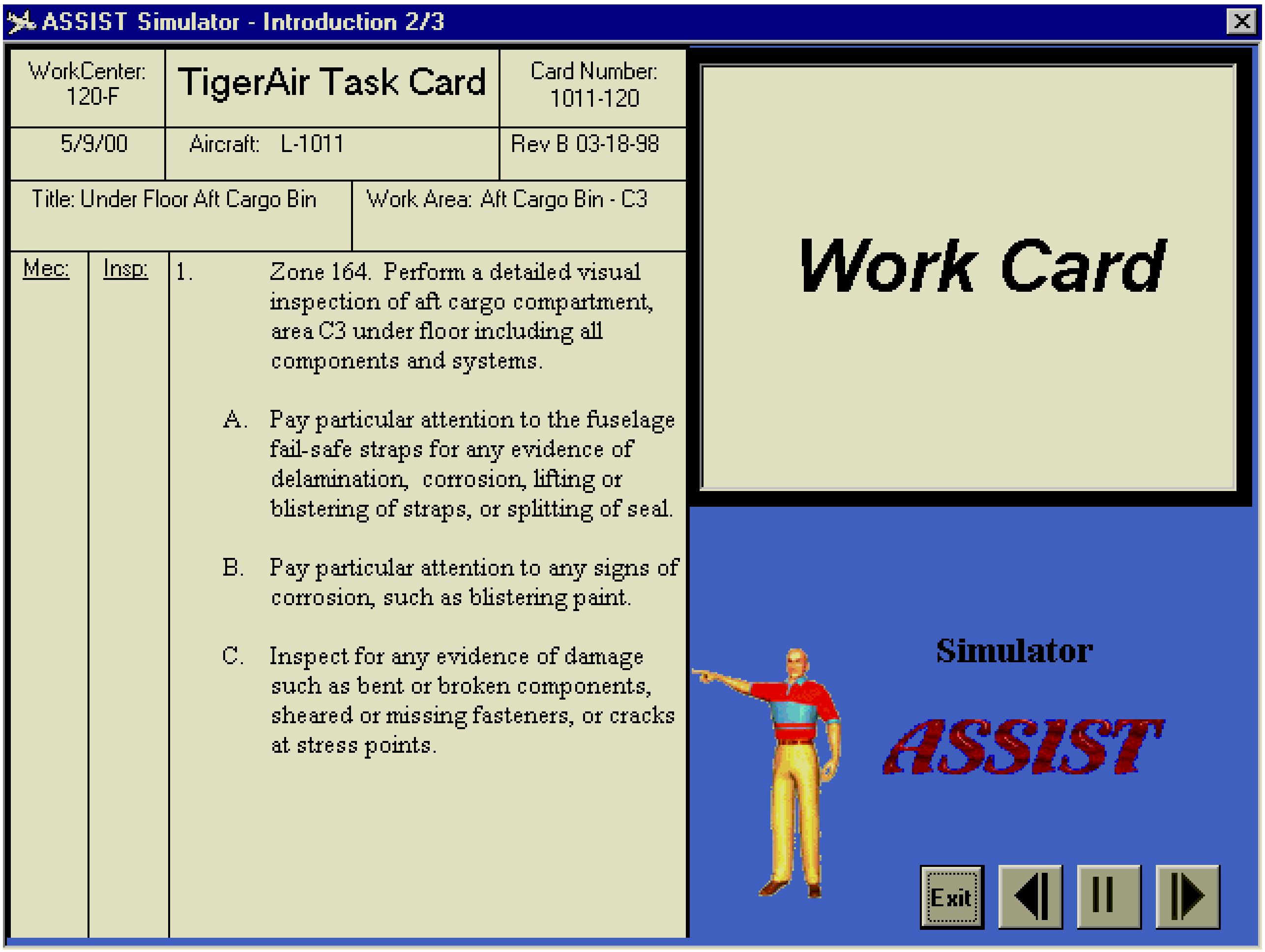

Figure 1.30 Work Card Used to for the Simulation in ASSIST

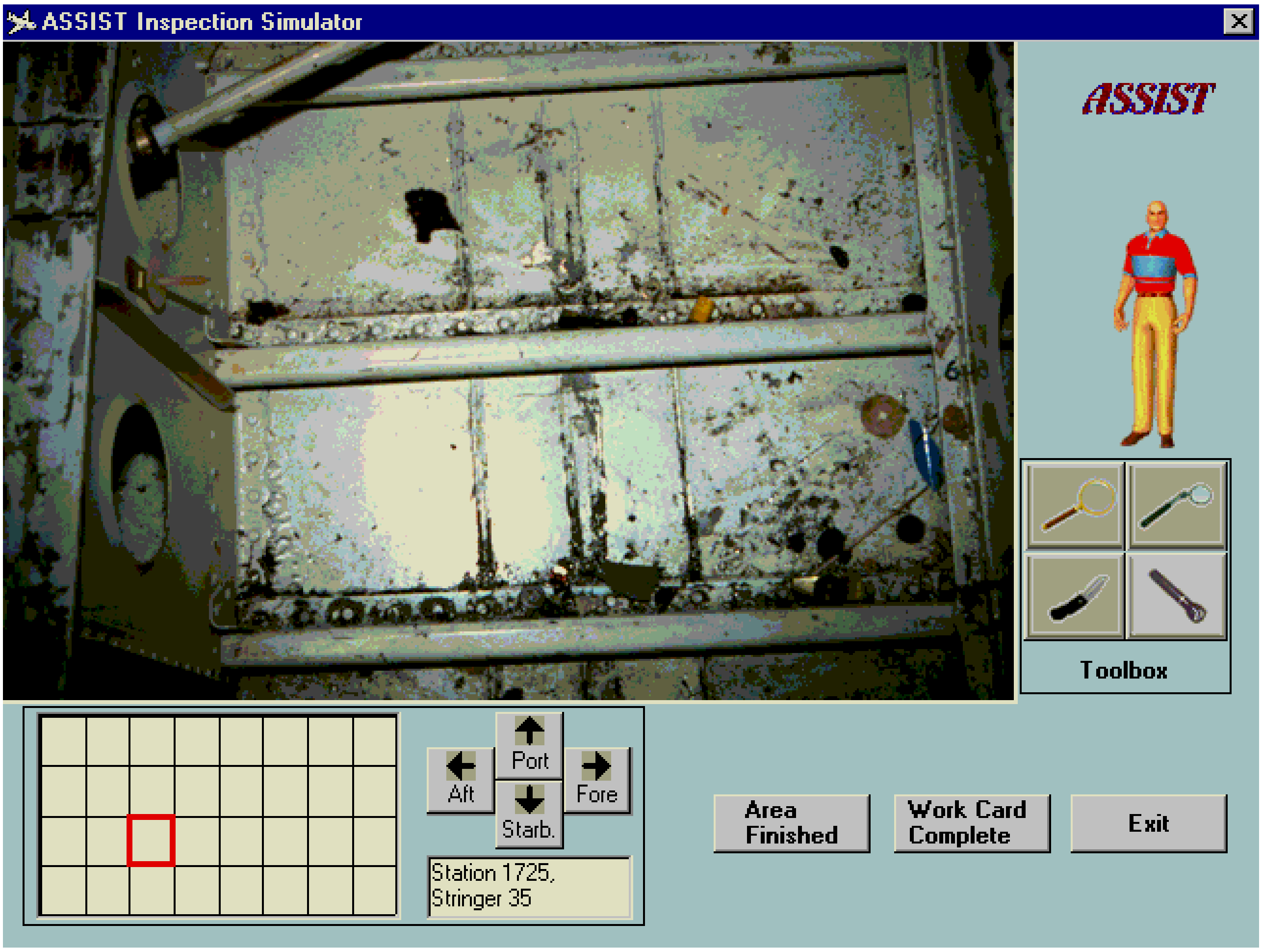

Figure 1.31 Simulation Module Containing a Picture of the Aft-Cargo Bin

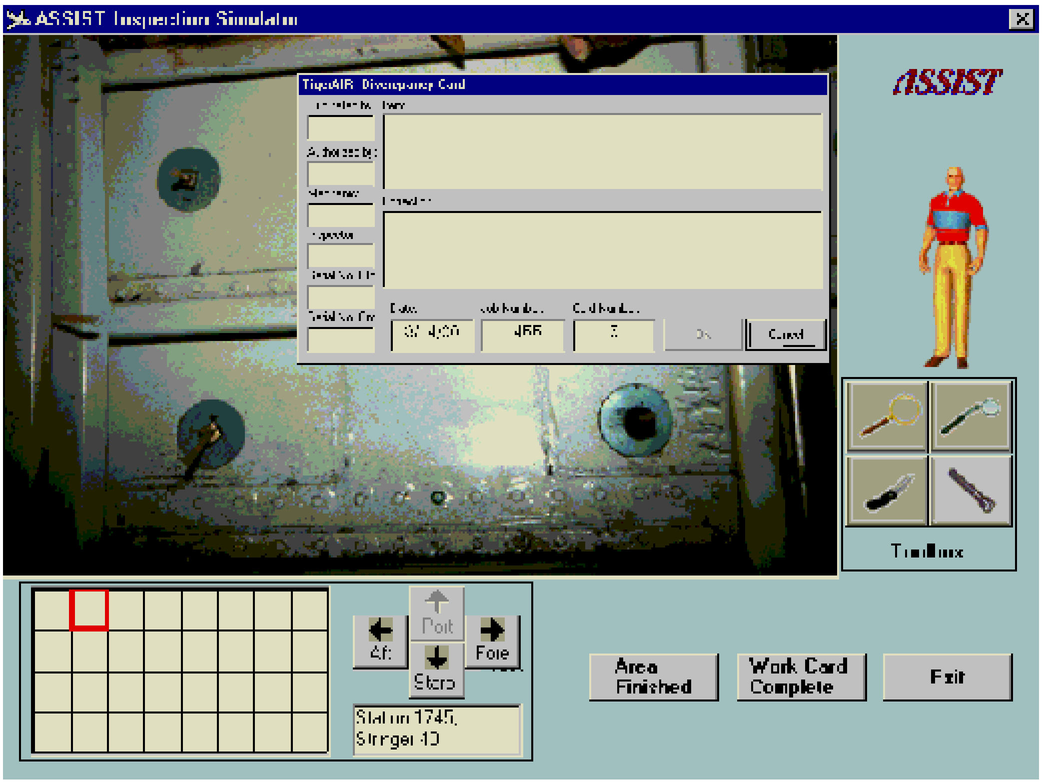

Figure 1.32 Non-routine card used to Write-up Defects Found in the Simulator

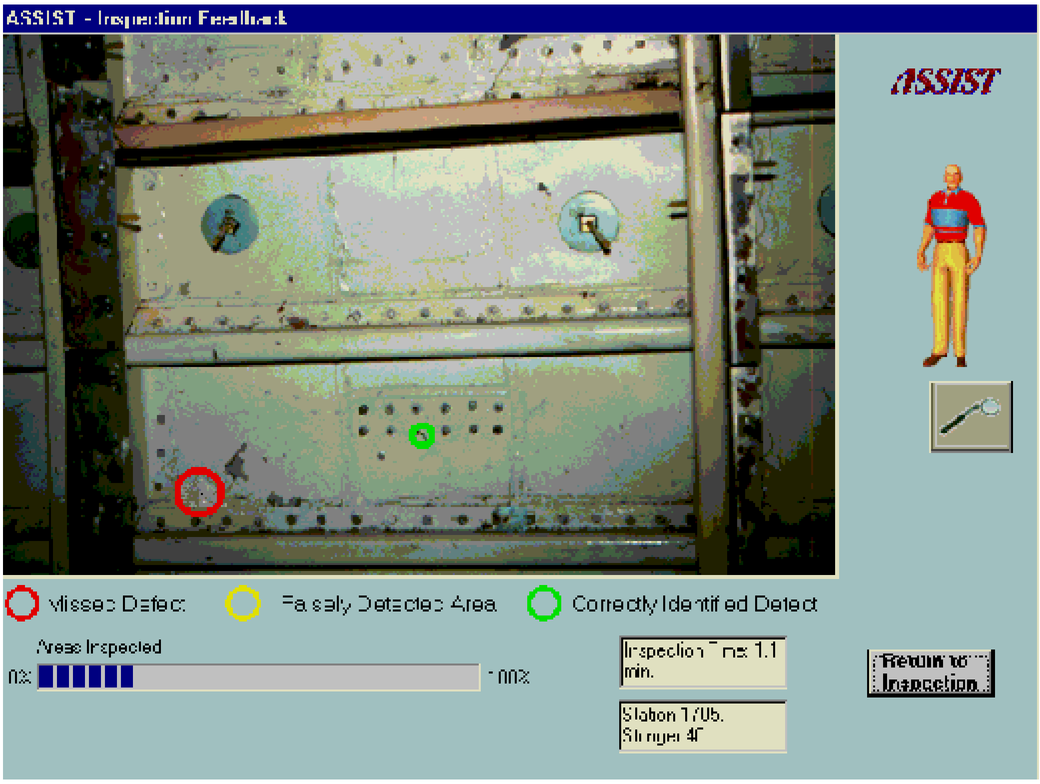

Figure 1.33 Feedback Provided in the Simulation Module

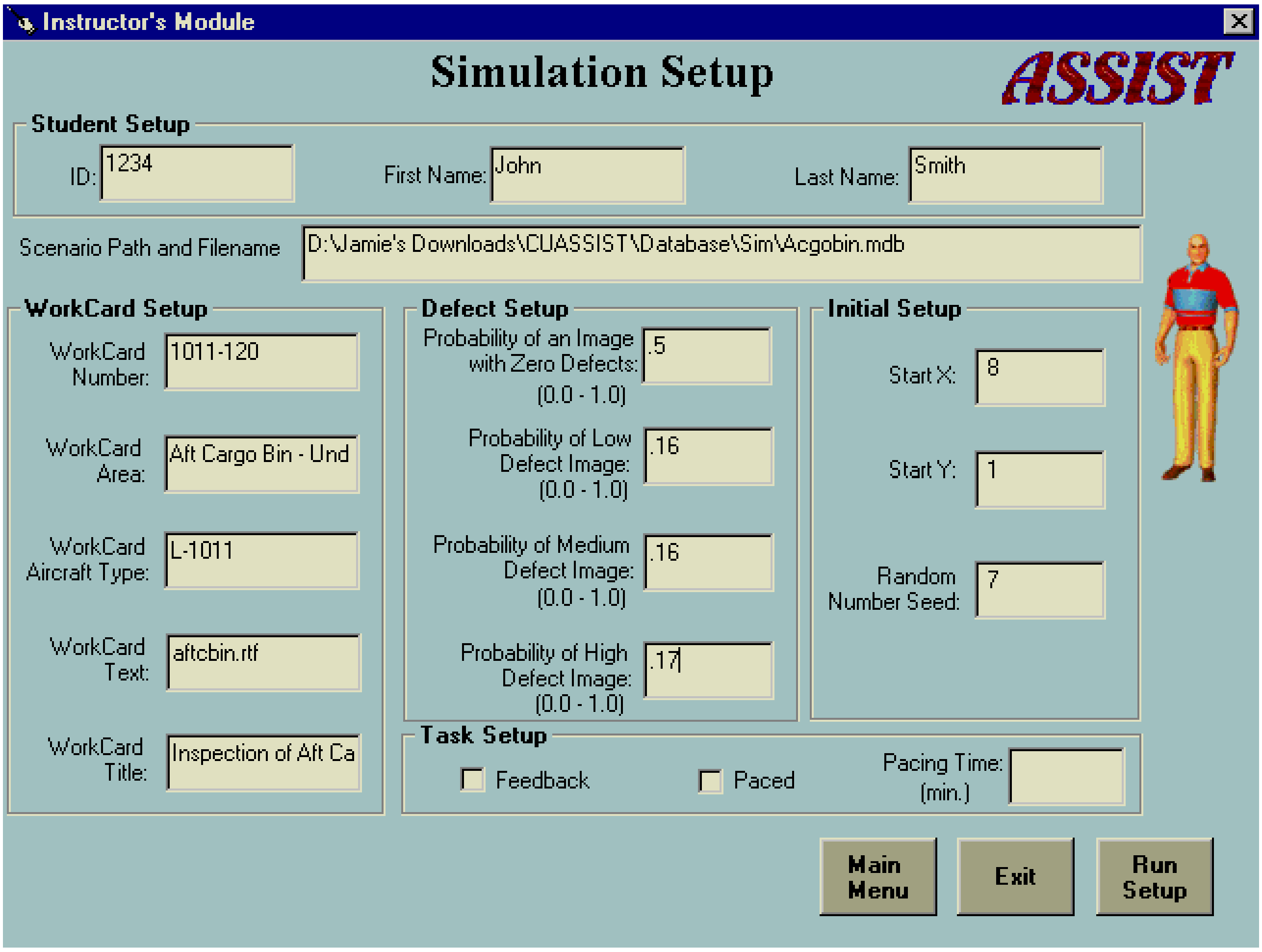

Figure 1.34 Simulator Setup Utility Shown for Unpaced Scenario

After completing the training, subjects in the training group and those in the control group performed the criterion inspection tasks: a visual inspection of 32 distinct search areas constituting one distinct and logical portion of the Aft-Cargo bin of an L-1011 wherein subjects searched for seven different types of defects. The probability, location and defect mix were all pre-specified using the parameter file. Initially, subjects performed the inspection task in the unpaced mode and then in the paced-mode so that the results of the unpaced trial could be used to determine the actual pacing conditions for the paced per-lot trial (Figures 1.34 through 1.35). In the paced mode subjects had a time limit for completion of the entire inspection task. Subjects were paced based on their individual unpaced times. To gauge their knowledge of inspection following training**,** subjects in both the groups completed the same Sections I and II of the knowledge test. Then, to test whether computer-based training transferred to performance on the job, all subjects completed a hangar floor test (Figure 1.36) wherein they were tasked to conduct a detailed inspection of the cargo compartment door (Figures 1.37 and 1.38). After completing this final test, the subjects were debriefed and thanked for their participation.

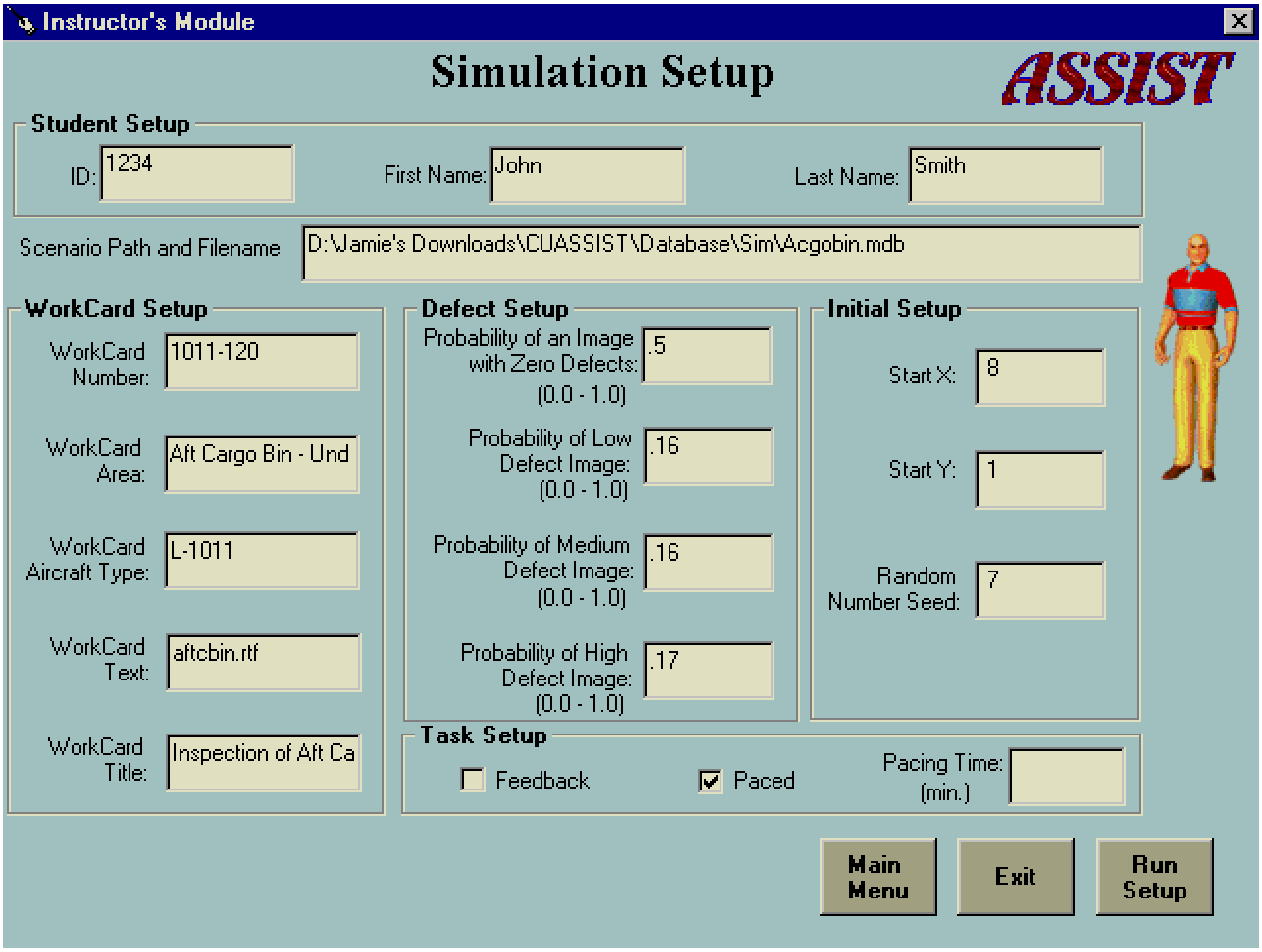

Figure 1.35 Simulator Setup Utility Shown for Paced Scenario

Hangar Floor Test

Scoring:

Correct Answer – all steps are correct and in the correct order [score = 5]
Partially Correct Answer – some steps are omitted or out of order; otherwise are
Wrong Answer – some information provided is incorrect [score = 1]

1. What are the major steps in initial inspection from beginning to end?

2. Task: Ask the inspector to follow the procedures from time of assignment by foreman.

   Task: Search for defects on the door and have inspector fill out non-routine work cards.

- Did you follow a pattern when visually inspecting? Describe the pattern.

- (for defects located) (for defects located) Did you look in certain areas for certain defects,

3. Presents improperly worded non-routines card and have the inspector find the errors. [SEE CARD]

4. What steps do you take after you finish the inspection of an area?

5. What are three steps in buy-back inspection?

Figure 1.36 Hangar Floor Test

B-767 PRODUCTION COUNT REV.DATE 10-09-98

TIME DAY ON/OFF	SUB. TOTALS	DETAILED INSPECTION OF CARGO COMPARTMENT DOORS
		1. Inspect FWD. Cargo Door. 2. Inspect AFT. Cargo Door. 3. Inspect Bulk Cargo Door.

ACTUAL HOURS

PWR REQ: N— Y— HYD—— PNEU—— ELEC——

SHIP	CK/BLK	DATE	JOB NO.	MIRS WO	WK.CTR.	OPN.NO.	EST STD	CARD NO.	SKILL
					242-01	57116	1.5		12

B-767 JOB DESCRIPTION REV.DATE 10-09-98

MECH.	INSPECTED BY	DETAILED INSPECTION OF CARGO COMPARTMENT DOORS
	1	1. Inspect FWD. Cargo Door.
	2	2. Inspect AFT. Cargo Door.
	3	3. Inspect Bulk Cargo Door.

PWR REQ: N— Y— HYD—— PNEU—— ELEC——

SHIP	CK/BLK	DATE	JOB NO.	MIRS WO	WK.CTR.	OPN.NO.	ATA CODE	CARD NO.	SKILL
					242-01	57116	52-00-00		12

B-767 OPN. NO. 57116 KEYWORD: INSPECT OPN. I

1. Inspect FWD. Cargo Door as follows:
   - A. Inspect Door Stops and visible adjacent cut-out structure within aircraft contour.
     - (1) Pay particular attention to Door Sills and Frame Chords. (Ref. MPD 5302-
       (Ref. Figure 2)
2. Inspect AFT. Cargo Door as follows:
   - A. Inspect Door Stops and visible adjacent cut-out structure within aircraft contour.
     - (1) Pay particular attention to Door Sills and Frame Chords. (Ref. MPD 5302-
       (Ref. Figure 1)
3. Inspect Bulk Cargo Door as follows:
   - A. Inspect Door Stops and visible adjacent cut-out structure within aircraft contour.
     - (1) Pay particular attention to Door Sills and Frame Chords (Ref. MPD 5302
       (Ref. Figure 3)

Figure 1.37 Hangar Floor Test: Workcard

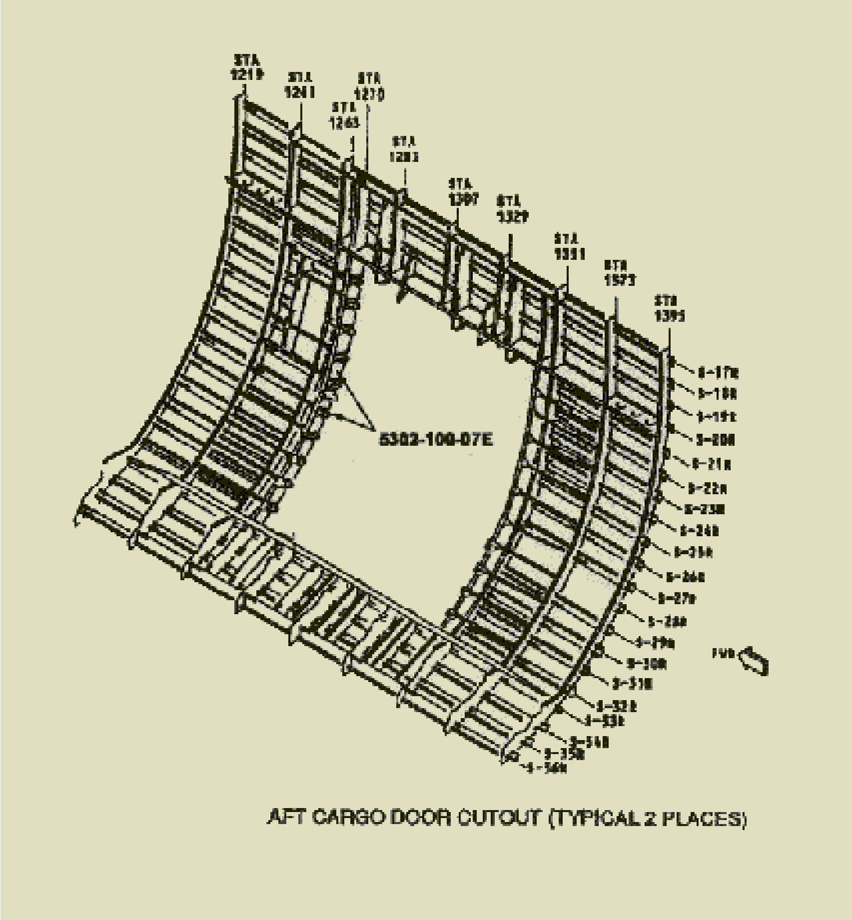

Figure 1.38 Hangar Floor Test : Workcard

Data Collection

Data was collected on the following measures:

- Knowledge Tests (Sections I and II): number of correct responses.
- Criterion Inspection task: Inspection time, misses, false alarms, percentage of defects correctly detected, non-routine card entries.
- Hangar Floor Test: performance test focused on inspection conducted in the hangar floor.

1.6 USABILITY and Performance Analyses

1.6.1 Usability Analysis

To test whether the ASSIST software met usability goals, inspectors, supervisors, and training personnel at aircraft maintenance facilities evaluated the software on specific usability dimensions, e.g., content, presentation, usefulness and format. Separate usability questionnaires were administered for the general and the simulation modules (Figures 1.39 and 1.40). The responses were recorded using a seven-point Likert scale, with one being very strongly agree and seven being very strongly disagree. The mean scores and standard deviations for each group were recorded (Table 1.4).

ASSIST: GENERAL INSPECTION MODULE – USABILITY QUESTIONNARIE

Content

1. The amount of information presented was adequate.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

2. The information presented is extremely relevant to my job as an inspector.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

3. The subjects were well covered.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

4. The information presented was understandable.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Presentation

1. The language used by the speaker was understandable.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

2. The screens were understandable.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

3. The information presented flowed smoothly.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Figure 1.39a Usability Questionnaire -ASSIST: General Module

4. The presentation was interesting.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

5. The narration in the modules helped in understanding the material.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

6. It was easy to navigate through the modules.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Usefulness

1. The knowledge gained from each of the following sub-modules was useful:

"Role of Inspection" Sub-module

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

"Safety" Sub-module

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

"Aircraft Review" Sub-module

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

"Factors Affecting Inspection" Sub-module

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

"Inspection Procedure" Sub-module

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Figure 1.39b Usability Questionnaire -ASSIST: General Module

1. The short questions presented during the final test were helpful in reinforcing what you learned.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

2. The information provided by the general module will help me in my job on the hangar floor.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

3. The information provided should be part of any inspection training.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

4. In addition to your OTJ and classroom training, all inspectors should be trained on the general module.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

5. The information is useful for anyone aspiring to be an inspector.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Format

1. The colors used on the screen did not distract from the task or cause eye discomfort.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

1. The buttons on the screen were easy to understand.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Figure 1.39c Usability Questionnaire -ASSIST: General Module

1. The time for the computer to process information did not frustrate you.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

2. You were satisfied with the interaction with the computer.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

3. The tutorial was effective in providing instruction.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

4. The colors used were pleasing.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Figure 1.39d Usability Questionnaire -ASSIST: General Module

ASSIST: SIMULATION INSPECTION MODULE

Content

1. The amount of information presented was adequate.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

2. The subjects were thoroughly covered.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

3. The information presented was understandable.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Presentation

1. The language used by the speaker was understandable.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

2. The screens were understandable.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

3. The information presented flowed smoothly.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

4. The narration in the modules helped in understanding the material.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Figure 1.40a Usability Questionnaire - ASSIST: Simulation Module

5. It was easy to navigate through the screens.

1 2 3 4 5 6 7

Very Strongly Disagree | Neutral | Very Strongly Agree

Usefulness

1. The knowledge gained from the "Introduction" sub-module was useful.

1 2 3 4 5 6 7

Very Strongly Disagree | Neutral | Very Strongly Agree

2. The inspection tools (scraping knife, magnifying glass, mirror, and flashlight) used during the "Testing" sub-module was realistic and helpful in looking for defects.

1 2 3 4 5 6 7

Very Strongly Disagree | Neutral | Very Strongly Agree

3. The feedback provided at the end of each screen was useful.

1 2 3 4 5 6 7

Very Strongly Disagree | Neutral | Very Strongly Agree

4. The feedback provided at the end-of-session was useful.

1 2 3 4 5 6 7

Very Strongly Disagree | Neutral | Very Strongly Agree

5. The defect write-up provided on the discrepancy card was useful.

1 2 3 4 5 6 7

Very Strongly Disagree | Neutral | Very Strongly Agree

6. This computer program will make a good component of your overall training.

1 2 3 4 5 6 7

Very Strongly Disagree | Neutral | Very Strongly Agree

Figure 1.40b Usability Questionnaire - ASSIST: Simulation Module

3. The information provided by the Simulation module will help me in my job on the hangar floor.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

4. The information provided should be part of any inspection training.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

5. In addition to your OTJ and classroom training, all inspectors should be trained on the simulation module.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

6. The information is useful for anyone aspiring to be an inspector.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

7. This training would be useful for periodic re-training of inspectors.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

8. This training was very realistic to the real-world of inspecting.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Format

1. The colors used on the screen did not distract from the task or cause eye discomfort.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Figure 1.40c Usability Questionnaire - ASSIST: Simulation Module

2. The buttons on the screen were easy to understand.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

3. The time for the computer to process information did not frustrate you.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

4. You were satisfied with the interaction with the computer.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

5. The tutorial was effective in providing instruction.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

6. The picture quality used for the aircraft was realistic.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

7. The picture quality of the defects was realistic.

1	2	3	4	5	6	7
Very Strongly Disagree			Neutral			Very Strongly Agree

Figure 1.40d Usability Questionnaire - ASSIST: Simulation Module

Table 1.4 Results from the Usability Questionnaire

Category	7 Point Scale		Mean Scores (S.D.)		Wicoxon Test

	1	7	General Module	Simulation Module	
Content	Very Strongly Agree	Very Strongly Disagree	5.66 (1.88)	5.27 (1.91)	$p<0.05$
Presentation	Very Strongly Agree	Very Strongly Disagree	5.72 (1.23)	5.48 (1.32)	$p<0.05$
Usefulness	Very Strongly Agree	Very Strongly Disagree	5.47 (1.52)	4.81 (3.07)	$p<0.05$
Format	Very Strongly Agree	Very Strongly Disagree	5.55(1.45)	5.14 (2.39)	$p<0.05$

A Cronbach's Coefficient Alpha (Cronbach, 1951), was calculated for the group of questions to ensure that it was appropriate to place them into a particular usability dimension (Tables 1.5, 1.6).

The Alpha Coefficient can be expressed mathematically as

Alpha = $$\left[\frac{k}{k-1}\right]\left[1-\frac{\sum_i Vi}{Vt}\right]$$

where

k = the number of questions combined,

Vt = the variance of the participants' total scores, and

Vi = the sum of the variances of the responses for each individual question.

Table 1.5 Cronbach's Alpha Coefficient: General Module				
Category	Var_s	Var_T	k	Alpha
Content	9.54	32.26	4	0.94
Presentation	5.48	17.35	6	0.82
Usefulness	12.27	61.76	10	0.89
Format	9.08	21.09	6	0.68

Responses for Usability

Table 1.6 Cronbach's Alpha Coefficient: Simulation Module				
Category	Var_s	Var_T	k	Alpha
Content	7.07	15.71	3	0.82
Presentation	7.02	14.25	5	0.63
Usefulness	32.95	364.50	12	0.96
Format	13.89	37.14	7	0.73

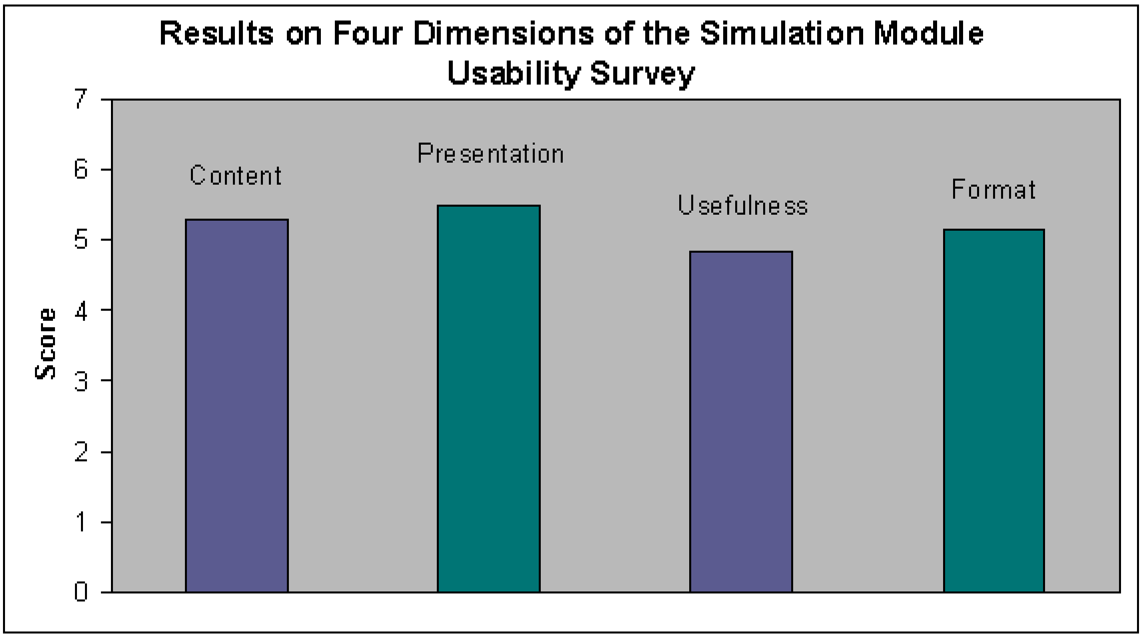

Figure 1.41 Results on Four Dimensions of the Simulation Module Usability Survey

To ensure that the questions would yield interpretable results about usability, the Cronbach's Coefficient Alpha should be greater than 0.5 and less than or equal to 1.0 (Cronbach, 1951). The alpha coefficients for all four dimensions were within the prescribed limits; thus, the questions were grouped into their respective categories. The results of the usability survey are summarized in Table 1.5, listing the mean and standard deviation for each usability dimension. Then, a Wilcoxon Signed Rank Test was used to determine whether the subjects preferred the system of each of the four different usability dimensions by comparing the actual mean scores versus the expected mean score of 4.0. The results revealed that the subjects favored the computer system (Figure 1.41) on all the four dimensions investigated (Tables 1.7 and 1.8).

Table 1.7 Usability Analysis: General Module

Category	Question	Likert Scale		Compared Mean	Mean	(S.D.)	Wilcoxon test
		1	7				
Content	1. The amount of information presented was adequate.	Very Strongly Disagree	Very Strongly Agree	4	5.45	(2.11)	($p<0.05$)
	2. The information presented is extremely relevant to my job as an inspector.	Very Strongly Disagree	Very Strongly Agree	4	5.48	(1.97)	($p<0.05$)
	3. The subjects were well covered.	Very Strongly Disagree	Very Strongly Agree	4	5.76	(1.98)	($p<0.05$)
	4. The information presented was understandable.	Very Strongly Disagree	Very Strongly Agree	4	5.93	(1.50)	($p<0.05$)
Presentation	5. The language used by the speaker was understandable.	Very Strongly Disagree	Very Strongly Agree	4	6.02	(0.82)	($p<0.05$)
	6. The screens were understandable.	Very Strongly Disagree	Very Strongly Agree	4	5.79	(0.88)	($p<0.05$)
	7. The information presented flowed smoothly.	Very Strongly Disagree	Very Strongly Agree	4	5.66	(1.31)	($p<0.05$)
	8. The presentation was interesting.	Very	Very	4	5.59	(1.61)	($p<0.05$)

		Strongly Disagree	Strongly Agree				
	9. The narration in the modules helped in understanding the material.	Very Strongly Disagree	Very Strongly Agree	4	5.41	(1.18)	(p<0.05)
	10. It was easy to navigate through the modules.	Very Strongly Disagree	Very Strongly Agree	4	5.86	(1.12)	(p<0.05)
Usefulness	11. The knowledge gained from each of the following sub-modules was useful:"Role of Inspection" Sub-module	Very Strongly Disagree	Very Strongly Agree	4	5.41	(0.75)	(p<0.05)
	12. The knowledge gained from each of the following sub-modules was useful:"Safety" Sub-module	Very Strongly Disagree	Very Strongly Agree	4	5.33	(1.03)	(p<0.05)
	13. The knowledge gained from each of the following sub-modules was useful:"Aircraft Review" Sub-module	Very Strongly Disagree	Very Strongly Agree	4	4.88	(1.24)	(p<0.05)
	14. The knowledge gained from each of the following sub-modules was useful:"Factors Affecting Inspection" Sub-module	Very Strongly Disagree	Very Strongly Agree	4	5.47	(1.06)	(p<0.05)
	15. The knowledge gained from each of the following sub-modules was useful:"Inspection Procedure" Sub-module	Very Strongly Disagree	Very Strongly Agree	4	5.40	(1.48)	(p<0.05)
Usefulness	16. The short questions presented during the final test were helpful in reinforcing what you learned.	Very Strongly Disagree	Very Strongly Agree	4	5.68	(1.22)	(p<0.05)
	17. The information provided by the general module will help me in my job on the hanger floor.	Very Strongly Disagree	Very Strongly Agree	4	5.31	(2.36)	(p<0.05)
	18. The information provided should be part of any inspection training.	Very Strongly Disagree	Very Strongly Agree	4	5.90	(1.95)	(p<0.05)
	19. In addition to your OTJ and classroom training, all inspectors should be trained on the general module.	Very Strongly Disagree	Very Strongly Agree	4	5.55	(2.18)	(p<0.05)
	20. The information is useful for anyone aspiring to be an inspector.	Very Strongly Disagree	Very Strongly Agree	4	5.75	(1.76)	(p<0.05)
Format	21. The colors used on the screen did not distract from the task or cause eye discomfort.	Very Strongly Disagree	Very Strongly Agree	4	5.41	(2.54)	(p<0.05)
	22. The buttons on the screen were easy to understand.	Very Strongly Disagree	Very Strongly Agree	4	5.76	(0.76)	(p<0.05)
	23. The time for the computer to process information did not frustrate you.	Very Strongly Disagree	Very Strongly Agree	4	5.69	(0.86)	(p<0.05)
	24. You were satisfied with the interaction with the computer.	Very Strongly Disagree	Very Strongly Agree	4	5.61	(0.74)	(p<0.05)
	25. The tutorial was effective in providing instruction.	Very Strongly Disagree	Very Strongly Agree	4	5.62	(1.82)	(p<0.05)
	26. The colors used were pleasing.	Very Strongly Disagree	Very Strongly Agree	4	5.24	(2.05)	(p<0.05)

Table 1.8 Usability Analysis: Simulation Module

Category	Question	Likert Scale	Compared Mean	Mean|(S.D.)	Wilcoxon test

		1	7				
Content	1. The amount of information presented was adequate.	Very Strongly Disagree	Very Strongly Agree	4	5.31	(1.95)	(p<0.05)
	2. The subjects were thoroughly covered.	Very Strongly Disagree	Very Strongly Agree	4	5.08	(1.97)	(p<0.05)
	3. The information presented was understandable.	Very Strongly Disagree	Very Strongly Agree	4	5.46	(1.03)	(p<0.05)
Presentation	1. The language used by the speaker was understandable.	Very Strongly Disagree	Very Strongly Agree	4	5.71	(2.33)	(p<0.05)
	2. The screens were understandable.	Very Strongly Disagree	Very Strongly Agree	4	5.08	(0.93)	(p<0.05)
	3. The information presented flowed smoothly.	Very Strongly Disagree	Very Strongly Agree	4	5.41	(1.01)	(p<0.05)
	4. The narration in the modules helped in understanding the material.	Very Strongly Disagree	Very Strongly Agree	4	5.31	(1.13)	(p<0.05)
	5. It was easy to navigate through the screens.	Very Strongly Disagree	Very Strongly Agree	4	5.77	(2.23)	(p<0.05)
Usefulness	1. The knowledge gained from the “Introduction” sub-module was useful.	Very Strongly Disagree	Very Strongly Agree	4	5.13	(3.70)	(p<0.05)
	2. The inspection tools (scraping knife, magnifying glass, mirror, and flashlight) used during the “Testing” sub-module were realistic and helpful in looking for defects.	Very Strongly Disagree	Very Strongly Agree	4	4.69	(2.42)	(p<0.05)
	3. The feedback provided at the end of each screen was useful.	Very Strongly Disagree	Very Strongly Agree	4	5	(2.60)	(p<0.05)
	4. The feedback provided at the end-of-session was useful.	Very Strongly Disagree	Very Strongly Agree	4	5.03	(1.69)	(p<0.05)
	5. The defect write-up provided on the discrepancy card was useful.	Very Strongly Disagree	Very Strongly Agree	4	5.12	(3.02)	(p<0.05)
	6. This computer program will make a good component of your overall training.	Very Strongly Disagree	Very Strongly Agree	4	4.97	(3.76)	(p<0.05)
	7. The information provided by the Simulation module will help me in my job on the hanger floor.	Very Strongly Disagree	Very Strongly Agree	4	4.23	(2.73)	(p<0.05)

1.6.2 Performance Analysis

The data was analyzed using a mixed between and within subjects design. Separate analyses of variance were conducted on the following performance measures: inspection time, percentage defects correctly detected, number of false alarms, number of misses, total score on non-routine cards, score on the knowledge test (sections I and II) and the score on the hangar floor test. The mean score for the different experimental conditions along with the ANOVAs are shown in Tables 1.9 through 1.22. Analyses of variance showed training was significant for the following performance measures: percentage correctly detected (Figure 1.43), number of false alarms (Figure 1.44), misses (Figure 1.45), total score on non-routine cards (Figure 1.46). Although, the effect of training for the post training trail for the knowledge test (sections I and II) was not statistically significant, looking at Figure 1.47, it can be seen that the training group reported higher scores on the post training trail for the knowledge test on both sections I and II. The effect of pacing was significant for the following performance measures: inspection time, percentage correctly detected, number of false alarms, misses, and total score on non-routine cards. Interestingly, analyses of variance did not reveal any significant differences between groups for the hangar-floor test (Figure 1.48).

Table 1.9 Performance Measures Table								
Group	**Inspector Number**	**Inspection time (min)**		**Percentage correctly detected**		**Number of false alarms**		**Number of misses**
		Unpaced	**Paced**	**Unpaced**	**Paced**	**Unpaced**	**Paced**	**Unpaced**
Trained Group	S1	26.60	27.02	45	40	13	40	11
	S2	33.23	16.45	45	45	6	2	11
	S3	49.67	32.73	60	60	35	32	8
	S4	57.38	13.50	60	65	29	27	8
	S5	38.98	39.22	45	65	23	73	11
	S6	35.50	30.70	60	70	30	43	8
	S7	57.83	35.70	50	55	36	46	10
	S8	37.73	29.75	50	55	35	42	10
	S9	39.52	30.28	50	70	29	39	10
	Mean	41.83	28.37	51.67	58.33	26.22	38.22	10.00
	Std. Dev.	10.81	8.41	6.61	10.61	10.45	18.67	1.32
Control Group	S10	48.35	46.50	30	60	15	34	14
	S11	40.50	29.17	20	45	14	22	16
	S12	69.37	33.70	35	40	24	12	13
	S13	9.30	6.27	15	15	13	29	17
	S14	18.12	11.29	15	20	7	11	17
	S15	21.58	19.24	35	35	2	5	13
	S16	63.49	40.28	45	70	12	6	11
	S17	55.46	31.52	40	50	20	20	12
	S18	63.14	30.47	30	65	27	32	14
	Mean	43.26	27.60	29.44	44.44	14.89	19.00	14.00

	Std. Dev.	22.14	13.09	10.74	19.11	7.88	11.08	2.14

Score on non-routine work cards

$$\text{Score} = \sum_{i=1}^{20} Si \qquad Si = 0, 0.5, 1$$

0 = Incorrect
0.5 = Partially correct
1 = Correct

i = Number of questions

Table 1.10 Inspection Time				
Source	**df**	**SS**	**MS**	**F**
Group	**1**	**.98**	**.98**	**0.001**
Pacing	**1**	**1906.20**	**1906.20**	**20.56***
Group * Pacing	**1**	**10.87**	**10.87**	**0.12**

*p<0.05

Table 1.11 Percentage Correctly Detected				
Source	**df**	**SS**	**MS**	**F**
Group	**1**	**2934.03**	**2934.03**	**11.61***
Pacing	**1**	**1056.25**	**1056.25**	**16.10***
Group * Pacing	**1**	**156.25**	**156.25**	**2.38**

*p<0.05

Table 1.12 Number of False Alarms				
Source	**df**	**SS**	**MS**	**F**
Group	**1**	**2100.69**	**2100.69**	**9.41***
Pacing	**1**	**584.03**	**584.03**	**5.95***
Group * Pacing	**1**	**140.03**	**140.03**	**1.43**

*p<0.05

Table 1.13 Number of Misses				
Source	**df**	**SS**	**MS**	**F**
Group	**1**	**117.36**	**117.36**	**11.61***
Pacing	**1**	**42.25**	**42.25**	**16.10***
Group * Pacing	**1**	**6.25**	**6.25**	**2.38**

*p<0.05

Table 1.14 Total Score on Non-routine Workcards				
Source	df	SS	MS	F
Group	1	101.67	101.67	10.11*
Pacing	1	29.34	29.34	10.78*
Group * Pacing	1	9.51	9.51	3.49

*p<0.05

Table 1.15 Knowledge Test Section I : Scores Obtained from set of 14 Questions			
	Subject	Before Training	After Training
Trained Group	T1	55	59
	T2	65	63
	T3	23	29
	T4	43	43
	T5	44	49
	T6	49	59
	T7	49	62
	T8	43	35
	T9	45	51
	Mean (Std. Dev.)	46.22 (11.24)	50.00 (12.20)
Control Group	C1	41	43
	C2	43	47
	C3	41	39
	C4	33	35
	C5	51	33
	C6	57	57
	C7	39	49
	C8	35	53
	C9	33	37
	Mean (Std. Dev.)	41.44 (8.11)	43.67(8.37)

Table 1.16 Knowledge Test Section I : Short Q & A (analysis)				
Source	df	SS	MS	F
Group	1	277.77	277.77	1.61
Condition	1	81.00	81.00	2.42
Group * Condition	1	5.444	5.44	0.16

*p<0.05

Table 1.17 Knowledge Test Section II : Scores Obtained from set of 30 Questions			
	Subject	Before Training	After Training
Trained Group	T1	25	28
	T2	29	29
	T3	28	28
	T4	28	29
	T5	25	28
	T6	29	30
	T7	28	27
	T8	29	29
	T9	28	29
	Mean (Std. Dev.)	27.67 (1.58)	28.56 (0.88)
Control Group	C1	27	28
	C2	28	30
	C3	25	25
	C4	25	26
	C5	26	25
	C6	24	28
	C7	27	27
	C8	28	23
	C9	25	28
	Mean (Std. Dev.)	26.11 (1.45)	26.67 (2.12)

Table 1.18 Knowledge Test Section II : Multiple Choice (analysis)				
Source	df	SS	MS	F
Group	1	26.69	26.69	9.59*

Condition	**1**	**4.69**	**4.69**	**2.17**
Group * Condition	**1**	**0.25**	**0.25**	**0.12**

*p<0.05

Table 1.19 Summary of F values from ANOVA (Tables 8-12)

Source	**Inspection Time (min)**	**Percentage Correctly Detected**	**Number of False Alarms**	**Number of Misses**	**Total Score non-routine work cards**
Group	0.00	11.61*	9.41*	11.61*	10.11*
Pacing	20.56*	16.10*	5.95*	16.10*	10.78*
Group * Pacing	0.12	2.38	1.43	2.38	3.49
*p<0.05					

Table 1.20 Summary of F values from ANOVA (Tables 14 & 16)

Source	**Short Q & A**	**Multiple Choice test**
Group	1.61	9.59*
Trial	2.42	2.17
Group * Trial	0.16	0.12
*p<0.05		

Table 1.21 Mean scores of Hangar Floor Test

	Subject	**After Training**
Trained Group	**T1**	**25**
	T2	**21**
	T3	**21**
	T4	**19**
	T5	**23**
	T6	**23**
	T7	**21**
	T8	**21**
	T9	**21**
	Mean (Std. Dev.)	**21.67 (1.73)**
Control Group	**C1**	**23**
	C2	**23**
	C3	**23**
	C4	**23**

	C5	19
	C6	17
	C7	19
	C8	14
	C9	23
	Mean (Std. Dev.)	20.44 (3.36)

Table 1.22 Hangar Floor Test (analysis)				
Source	df	SS	MS	F
Group	1	6.72	6.72	0.94
*p<0.05				

Figure 1.43 Performance Measure: Percentage of Correctly Detected Defects

Figure 1.44 Performance Measure: Number of False Alarms

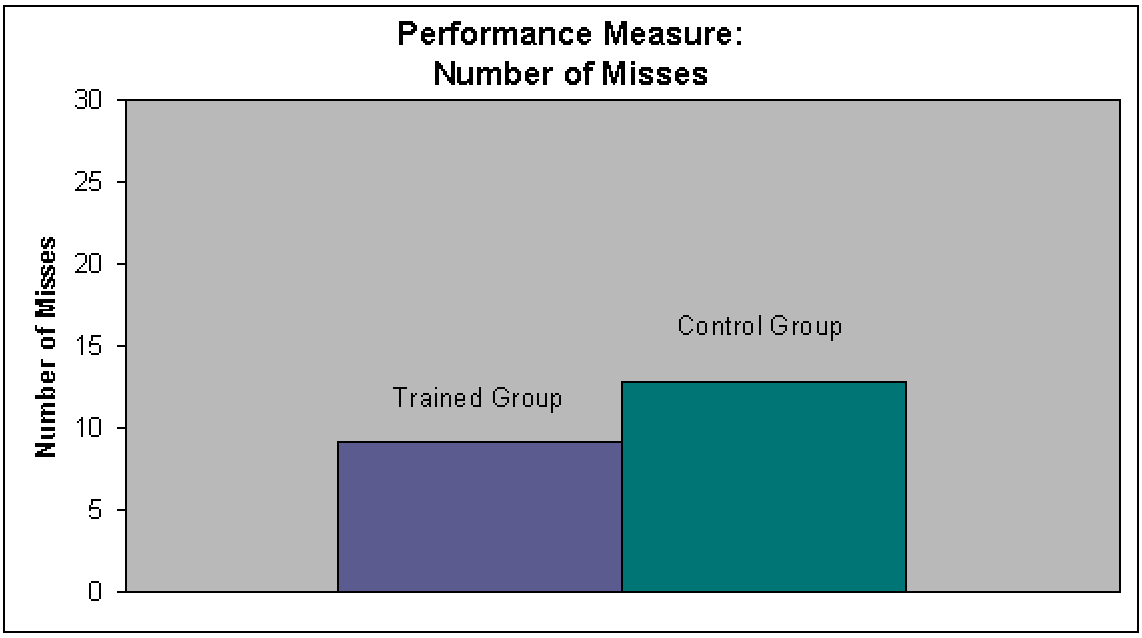

Figure 1.45 Performance Measure: Number of Misses

Figure 1.46 Performance Measure: Total Score on Non-routine Work Card

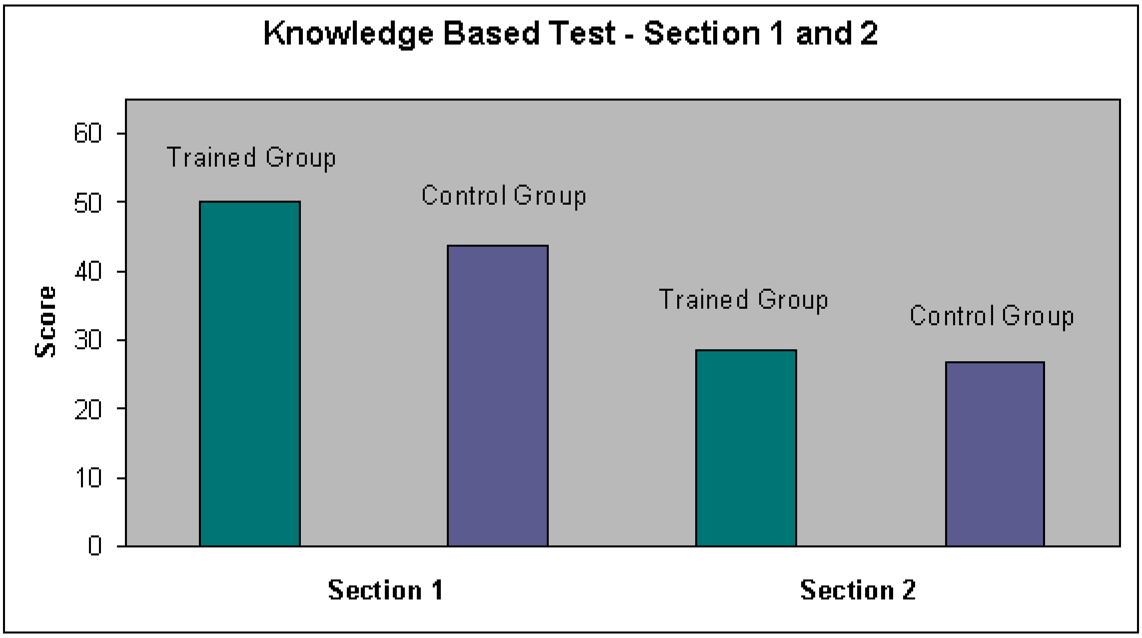

Figure 1.47 Performance Measure: Knowledge Based Test – Section 1 and Section 2

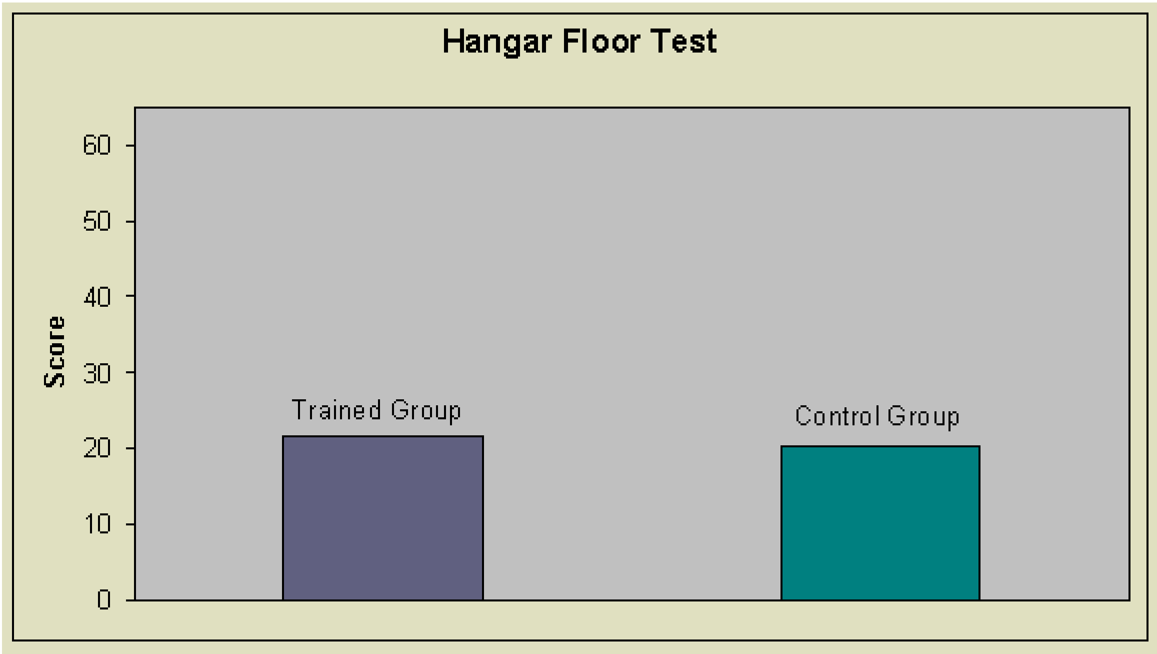

Figure 1.48 Hangar Floor Test

The results are unequivocal as to the usefulness of the system as perceived by the inspectors and supervisors. The usability analysis clearly demonstrates that the system was well-liked and easy to use. This is a testament to the task analytic and the iterative development methodology used in developing ASSIST. The system developers worked closely with aircraft maintenance personnel--inspectors, supervisors, training departments and quality assurance staff--in developing the system to ensured it was not only appropriate in its content and addressed the inspection training needs of aircraft maintenance organization but also user-friendly.

The results of this study are encouraging as to the effectiveness of computer-based inspection training and specifically ASSIST in improving performance. Performance of the training group significantly improved on the criterion inspection task, the inspection of Aft-Cargo bin of L-1011, following training. Of greatest interest was the increase in the percentage of defects detected and the reduction in the number of misses for the training group compared with that for the control group. The training group detected a significantly greater number of defects and missed fewer. This has implications for on the job performance where detection of defects and having a low number of misses are critical to improving inspection performance and ultimately aviation safety.

Moreover, inspectors assigned to the training group also reported higher scores on the non-routine cards following training compared to the control group. These scores measure the correctness and appropriateness of the information entered by the inspector using the non-routine cards following the identification of defects. Subjects responses entered on the non-routine card were scored based on a "standard or correctly completed non-routine card." The information entered on these cards is critical for follow-up maintenance action because incorrect entries or incorrect information can result in erroneous maintenance action. Significantly improved performance for the training group in completing the non-routine card has information has obvious implications for incorporating ASSIST training as part of regular inspection training. The training program also resulted in improved inspection knowledge about the job. The content of ASSIST helped the inspectors in the training group develop a better understanding of the "inspection job" as indicated by the higher scores on the post-training knowledge test, a response supported by the subjects' feelings regarding the appropriateness of the content as shown by the high scores assigned to content related questions on the usability questionnaire for both the general and simulation modules, specifically questions 1, 2 and 3 for the general modules and questions 2 and 3 for the simulation module.

Inspectors reported that the information provided by the general and simulation modules should be part of any inspection training. Moreover, they also stated that ASSIST training should be incorporated into the existing training for inspectors. Although the hangar floor test did not show significant differences between the two groups, these results were expected. Unlike the simulation tests in which there was greater experimental control, the hangar floor test was conducted in an uncontrolled hangar environment. Moreover, the hangar floor tests were conducted following the knowledge test, suggested that performance on the latter may have resulted in all subjects spending extra time reviewing material on their own, thus explaining the lack in sensitivity to inspection training.

1.7 CONCLUSIONS

In summary, the results have demonstrated the benefits of a well-designed computer based inspection training program. ASSIST not only improved performance but also was well accepted by inspectors. The following specific conclusions can be drawn from this study.

1. Improved Inspection Performance: Training using ASSIST translated into improved knowledge of the inspection task, resulting in reduced errors in the form of a significantly higher percentage detected, fewer misses and more correct write-ups for non-routine cards.

2. High Level of User Satisfaction: Usability evaluation clearly revealed that inspectors with different levels of computer experience could easily use a computer-based training tool. The high scores obtained for the various usability dimensions is a testament to the task analytic and iterative and customer focused methodology employed in development of ASSIST.

3. Standardized Method for Inspection Training: ASSIST can help standardize the aircraft inspection training process by ensuring similar content across inspection training curriculums.

4. Completeness: Inspectors can be exposed to a wide variety of defects with varying degrees of severity at different locations through the use of a library of defect images. Inspectors can also be trained on less frequently occurring critical defects.

5. Adaptability: ASSIST can be modified to meet the needs of individual inspectors. Batch files of images can be created to train inspectors on particular aspects of the inspection task with which they have the greatest difficulty. Thus, the program can be tailored to accommodate individual differences in inspection abilities.

6. Efficiency: Since the training will be more intensive, the trainees will be able to become more

skilled in a shorter period of time.

7. Integration: The training system will integrate different training methods, for example, feedback training, feed-forward training, and active training into a single comprehensive training program.

8. Certification: ASSIST can be used as part of the certification process. Since the record keeping process can be automated, instructors can more easily monitor and track an individual's performance, initially for training and later for retraining.

9. Instruction: ASSIST could be used by instructors in FAA certified A&P schools for training. Under these conditions, for example, aircraft maintenance technicians could gain exposure to defects on wide-bodied aircraft that they might not have otherwise.

The results obtained from these studies have obvious future implications. The following specific extensions are envisioned by the authors and will be addressed as part of Year 2 activities.

1.7.1 Retraining

The results of this research have clearly demonstrated that computer-based training can play a role in aircraft inspection training. However, we still do not know how often this training should be conducted. Unless we answer this question it will be difficult to sustain a high-level of performance over time. An inspector could be looked upon as an inspection device that needs to be re-calibrated at regular intervals to ensure that it is operating correctly. Hence it is important that we identify the frequency and intensity of the retraining effort.

Individual Differences

Although, the training group showed significant improvements in performance, we still do not know whether the training was effective for all inspectors because as literature has shown, large differences exist in inspection abilities. Unless we answer this very important question, developers of training program will tend to design strategies insensitive to individual differences in aircraft inspection abilities. In light of this situation, it is clear that we must identify training strategies to compensate for individual differences in inspection abilities to raise performance to a higher level.

Resource and Organizational Support: If aircraft maintenance organizations are to implement computer based inspection training and develop an overall training strategy that integrates CBT with existing alternate delivery systems, both classroom and OJT, it is clear that we must provide them with guidance on how to embark upon such an effort including the identification of resources--human, material, and equipment--and steps to implement successfully an overall training program. Only then can maintenance organizations use the results of this research to improve performance of inspectors and reduce errors.

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